Effectiveness of school-based nutrition interventions in sub-Saharan Africa: a systematic review

Abstract

Objective: To evaluate the effect of school-based nutrition interventions (SBNIs) involving school children and adolescents in sub-Saharan Africa (SSA) on child nutrition status and nutrition-related knowledge, attitudes and behaviour.

Design: A systematic review on published school nutrition intervention studies of randomised controlled trials, controlled clinical trials, controlled-before-and-after studies, or quasi-experimental designs with control. Nine electronic bibliographic databases were searched. To be included, interventions had to involve changes to the school's physical and social environments, to the school's nutrition policies, to teaching curriculum to incorporate nutrition education, and/or to partnership with parents/community.

Setting: Schools in SSA

Participants: School-aged children and adolescents, aged 5-19 years

Results: Fourteen (14) studies met our inclusion criteria. While there are few existing studies of SBNIs in SSA, the evidence shows that food supplementation/fortification is very effective in reducing micronutrient deficiencies and can improve nutrition status. Secondly, school nutrition education can improve nutrition knowledge, but this may not necessarily translate into healthy nutrition behaviour, indicating that nutrition knowledge may have little impact without a facilitating environment. Results regarding anthropometry were inconclusive, however, there is evidence for the effectiveness of SBNIs in improving cognitive abilities.

Conclusions: There is enough evidence to warrant further trials of SBNIs in SSA. Future research should consider investigating the impact of SBNIs on anthropometry and nutrition behaviour, focusing on the role of program intensity and/or duration. To address the high incidence of micronutrient deficiencies in low-and middle-income countries, food supplementation strategies currently available to school children should be expanded.

Keywords: *school children, nutrition intervention, anthropometry, micronutrients, food fortification, sub-Saharan Africa (SSA)*

INTRODUCTION

Childhood and adolescence are extremely important developmental stages in life. These early years are when key foundations are laid for adult health and economic well-being[1, 2]. The influence of childhood experiences on later adult life is well documented[1, 3-5]. Therefore, developing healthy nutrition behaviours in childhood may help to prevent not only under-nutrition, stunting and acute child nutrition problems, but also chronic, long-term health challenges such as obesity, cardiovascular diseases, type 2 diabetes and stroke[3, 6, 7]. Further, there is increasing evidence of a double burden of malnutrition, characterised by the co-existence of undernutrition/micronutrient deficiencies along with energy overnutrition or diet-related non-communicable diseases[8]. Encouraging healthy nutrition among children and adolescents can be an effective primary prevention strategy for reducing the risk of many non-communicable diseases. Poor child nutrition creates economic and social challenges among the vulnerable[9]. Particularly, under-nutrition has been linked to suboptimal brain development, which negatively affects educational performance and economic productivity[10-12]. Child malnutrition has been a major health problem in many low-and middle-income countries (LMICs). To reduce global health inequities, the World Health Organisation (WHO) has emphasized the key role of establishing positive early childhood experiences in health and in education[13]. Consequently, at the World Education Forum in Dakar, a framework that aimed at Focusing Resources on Effective School Health (FRESH) was launched in recognition of the importance of School Health and Nutrition (SHN) as a priority area for education sector plans[14]. Since then, the presence and scope of SHN has grown widely globally[15]. Specifically, between 2000-2015, SHN grew substantially in Education Sector Plans in SSA with school enrolment also rising from 83% in 2000 to 91% in 2015[15].

Since children spend a substantial proportion of their lives in the school setting, from a public health perspective it makes sense to make schools as healthy as possible. Schools can offer an optimal setting to promote healthy eating habits[16-20]. They can provide a unique system for the delivery of cost-effective public health interventions since they have a large reach over the child population[21]. More importantly, in LMICs with limited resources, the evidence indicates that effective school health promotion can offer a strong return on investment [22]. Investment in these formative years in childhood can reduce health inequity and create healthy adults. Indeed, schools are an obvious place to facilitate this social investment given the inextricable relationship between education and health [23].

According to the 2015 Millennium Development Goals (MDG) report, the prevalence of stunting among children has fallen in all regions except SSA, where the numbers increased by about one third between 1990 and 2013[24]. Thus, while in 2015, 24.5% and 15% of children globally were stunted and underweight respectively, the African region and South East Asia recorded the highest prevalence of undernutrition, with the former accounting for 39.4% of the stunted and 24.9% of the underweight [24]. This clearly indicates that malnutrition remains a major public health concern in the sub-region[8, 24-26]. In addition, whereas the average consumption of fruit and vegetables was below the WHO recommendations in all WHO regions, African, South East Asian and South American countries reported the least intake, where school children typically consumed less than 300 grams per day[27]. These statistics show that investigating and promoting child nutrition in SSA must be a public health priority, especially if the region is to meet the WHO global nutrition target of improving child nutrition by 2025. As a mediating measure for poor child nutrition in the sub-region, WHO and UN have implemented the Renewed Efforts Against Child Hunger and undernutrition (REACH), Scaling Up Nutrition (SUN)[8] and Accelerating Nutrition Improvement (ANI)[26] initiatives.

Poor nutrition of school children can be an important barrier affecting their health status, and thus access to education and academic achievements[15, 17, 28]. While the first 1000 days of a child's life remain crucial, school-aged children have the potential for catch-up growth[11] making them a suitable age group to target with well-designed nutrition interventions[17]. As a result, a number of initiatives have been promulgated globally to improve SHN, including but not limited to the FRESH approach[20], Health Promoting Schools[23] and Nutrition Friendly School Initiatives[29]. Several studies and reviews have evaluated the effectiveness of SHN programs globally[16, 21, 30-33]. Findings appear to support the effectiveness of multi-component, SBNIs in improving nutrition status and nutrition-related Knowledge, Attitude and Behaviour (KAB)[16, 18, 21]; however, evidence is inconsistent in terms of the actual impact of SBNIs[16, 30, 31, 34]. A preliminary review indicated that no systematic review that evaluates the effectiveness of SBNIs in SSA has been published. Therefore, this review aims to evaluate the effectiveness of SBNIs involving school children and adolescents in SSA on child nutrition status and nutrition KAB outcomes.

METHODS

The reporting style of this review is based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) Guidelines[35].

Eligibility criteria

Inclusion criteria: Studies were included based on:

- *Setting:* Schools in SSA
- *Type of Interventions:* SBNIs involving at least one of the following: a) changes to the school's physical and social environments; b) changes to school's nutrition policies; c) changes to teaching curricula to incorporate nutrition education; d) partnership with parents/community
- *Participants:* School children and adolescents, aged 5-19 years.
- *Study design*: Randomised controlled trials (RCTs, including cluster RCTs), controlled clinical trials, controlled before and after studies or quasi-experimental designs with control.
- *Outcomes of interest*: a) changes in physical indicators/anthropometry; b) changes in nutrition KAB; c) biochemical outcomes and d) psychosocial outcomes. Assessment of measures did not form part of eligibility criteria for initial screening of studies during the electronic search.
- *Period:* No date limit was set. Our last search was done on January 20, 2019
- *Language:* Studies reported in English
- *Publication status:* Published

Exclusion criteria:

- Surveys, observational or case studies, theses, policies and commentaries.
- Government school feeding interventions which also met the 'type of study/intervention' criteria.
- Other research reports of included studies

Information sources*:* The following electronic bibliographic databases were searched: Cochrane Library, MEDLINE, EMBASE, PubMed, CINAHL plus, PsycINFO and ProQuest. In addition, Informit, Health Collection and Scopus were searched. We also hand-searched reference lists of previously published systematic reviews on SHN[16, 21, 30-33]. Reference lists of included studies and the Public Health Nutrition Journal were also hand-searched. Corresponding authors of included studies, which required further clarification, were contacted through e-mail to find out if the articles we forwarded to them were 'twin' reports or if they knew of similar studies to theirs that they could recommend. Authors of 6 studies[28, 34, 36-39] were contacted and four of them[34, 36-38] responded.

Search: All available literature on SBNIs in SSA was screened independently by two members of the review team (PK & DS) using study titles and abstracts. The systematic search started in November 2018 and ended on January 20, 2019. Where reviewers were not sure of the eligibility of a study for inclusion, the entire document was downloaded for a full text screening. The Bolean search terms 'AND', 'OR' and '*' (for truncation) were applied: *'school-based nutrition'* or *'school nutrition intervention*'* or *'school nutrition program*'* or *'school meals'* or *'school breakfast'* or *'school lunch'* or *'school diet'* or *'school food' or 'school nutrition education'* AND *Sub-Saharan Africa* or *SSA or Angola,* or *Benin or…Zimbabwe* (all SSA countries were listed, see table 1 in the appendix).

Study selection: Both quantitative and qualitative studies were searched for during the initial search and no language limit, date limit or design limit was set during the screening stage although, some of those restrictions were applied later using the inclusion criteria. Search strategies were created by a university librarian with expertise in systematic review researching. For transparency and inter-rater reliability, two of the review team members independently screened study titles and abstracts against the inclusion criteria. Full reports for all titles that appeared to meet the inclusion criteria were retrieved. During the electronic database search stage, consensus meetings were held by two of the reviewers (PK, DS) to discuss eligibility of studies about which they had a divergent view. In such cases, a third review team member (LV or PL) was consulted for an opinion.

Data collection process: Data extraction matrix was developed with Microsoft Excel by PK and verified by DS. The reliability of the extraction matrix was tested by piloting data entry of the first 10% of included studies. Data extracted were information on authors' names, title of study, study aims, participants, intervention, comparators, outcomes (PICO), demographics, design, intervention duration and authors' conclusions. To avoid double counting and to synthesize data from multiple reports on the same intervention ('companion' reports), we juxtaposed names of authors, sample size, the outcomes and comparisons used. We considered all reports on a single intervention, but we did not include all companion reports. Only one of such reports was included. The final decision for inclusion or examining the full-text report to determine eligibility was not done by one reviewer but independently by three review members

(DS, LV, PL) representing public health physicians, epidemiologists, methodologists and content area experts.

Assessment of risk of bias within studies: To assess studies for risk of bias, we extracted information using the Cochrane 'Risk of bias' tool (described in chapter 8 (section 8.5) in the Cochrane Handbook for Systematic Reviews of Interventions[40]: i.e. random sequence generation, allocation concealment, blinding, incomplete outcome data such as dropouts, and selective outcome reporting. In addition, we assessed study quality using the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies[41]. Due to the public health nature of the review topic, we only report methodological rigour of studies based on the EPHPP tool (Appendix, table 3). For each included study, each criterion was rated as either *'strong', 'moderate'* or *'weak',* and then summed up to obtain an overall score (termed as 'global rating') for each paper.

RESULTS

Study selection: After initial screening of titles and abstracts, 1,041 records were identified through database searching. The records were exported to EndNote[x9] software where duplicates were removed; 602 records remained. After further analysis, 558 records were considered not relevant based on the eligibility criteria and were excluded. Following an assessment of study titles and abstracts, full texts of 76 studies were retrieved for further review for eligibility. Out of these, two reviewers (DS and PK) agreed that 44 studies were potentially eligible for full text analysis. Subsequently, only 14 studies[34, 36-39, 42-50] met our pre-specified inclusion criteria; 30 of the potentially eligible articles were excluded as those studies were either 'companion' reports of studies already included (n=7); school nutrition surveys/case studies (n=14) which mainly involved assessments of anthropometry and/or nutrition KAB[51-53]; analyses of perception and practice of healthy eating among teachers and parents, and development of school food gardens as nutrition tools[54-56]; RCTs of government school feeding initiatives (n=4)[28, 57, 58]; or SBNIs on pre-schoolers aged, <5 years (n= 5, these consisted mainly of school-and-community nutrition interventions with parental involvement[59-62]. Sixteen (16) records were identified through other sources, such as from reference lists of included studies. Figure 1 presents a flow chart of the review process.

Figure 1:

Study characteristics

Of the fourteen studies, half took place in South Africa and the other seven were from Botswana, Burkina Faso, Kenya, Nigeria and Tanzania. Three were controlled before and after trials[45, 48, 50] and 11(78.6%) were RCTs with 3 double-blind controlled trials[39, 44, 49]. All included studies assessed child nutrition status or nutrition KAB, either as primary or secondary outcomes. All but four of the studies[45-48] reported on anthropometric status. Three studies assessed cognitive outcomes through cognitive tests[37, 42, 44]. Nutrition behaviour outcomes were assessed in seven studies[34, 42, 43, 45-48] and nutrition knowledge was reported by only three[34, 45, 48]. Intervention duration varied from 3 weeks[48] to 3 years[34]. See table 2 in the appendix for details on the characteristics of included studies. All studies were conducted within the last two decades. Specifically, seven were published after the year 2010; only one was conducted before the year 2000[37]. The total number of participants involved in our analysis of this review was 6,837 school children, aged 5-19 years, from 121 schools. There was a minimum of one school in a study[37] to a maximum of 39 schools[36]. A majority of the participants (71% or 4,847 pupils) were aged 6-12 years. The average number of pupils per study was 488; only two of the studies[45, 48] had fewer than 200 participants.

Risk of bias within studies

Ten papers (71.4%) were rated as being of *'strong'* methodological quality, three (21.4%) were rated as *'moderate'* while one (7.2%) was rated as *'weak'*. Thus, the quality of the evidence of included studies varied, both between studies and across the different domains of potential bias within studies. Many of the studies were rated as being susceptible to *'high risk of bias'* on the *'blinding'* criterion. Only six studies stated explicitly that outcome assessors were not aware of the intervention status of participants. Although, as noted above, it was undoubtedly difficult to totally blind outcome assessors and participants since these were public health interventions. Drop-out rates varied from 0%[45, 48] to 43%. The drop-outs were mostly reported in terms of numbers and/or reasons per group in all cases except one[42]. One study lost nearly 50% of participants to drop-outs[45]. Table 3 presents details on the *'risk of bias'* within individual studies.

Intervention effects

a. Physical outcomes/Anthropometry

Weight and height gains were measured in kilogram (kg) and in centimetres (cm) respectively. Study children were classified as stunted, underweight or overweight if their 'z' score of

Height-for-age (HAZ), Weight-for-age (WAZ) and Body Mass Index (BMI)-for-age (BAZ) respectively were ± 2 standard deviation from the mean of the WHO reference population[63]. Of the studies which assessed anthropometric status, eight specifically reported on prevalence of child stunting[36-38, 42-44, 49, 50], six reported on wasting[37, 38, 43, 44, 50] and seven on BMI[34, 36, 39, 43, 44, 49, 50]. Although Kugo et al.[39] did not assess prevalence of stunting and wasting, their study and that of Abrams et al.[50] added mid-upper arm circumference (MUAC) and triceps skin fold assessment[39] to their measures.

In terms of intervention effects on outcomes, Stuijvenberg et al.[37] presented evidence that fortification of biscuits with iron, iodine and β-carotene (vitamins) had no favourable effect on anthropometric measures. Other results[50] indicated that compared with a control beverage, children who consumed fruit-flavoured Beverage Fortified with Micronutrients (BeForMi) of 240mL servings per week for 8 weeks had significant changes ($p = 0.01$) in BMI, MUAC, WAZ and total weight. In addition, at a follow-up, mean incremental changes in weight (1.79 vs 1.24 kg), height (3.2 vs 2.6 cm), and BMI (0.88 vs 0.53) were also significantly higher in an orange-flavoured BeForMi group than in a nonfortified group[49]. Moreover, micronutrients fortification or sugar alone in a beverage had a relative lowering effect on WAZ relative to controls (micronutrients -0.08; 95% CI -0.15, -0.01; sugar -0.07; 95% CI -0.14, -0.002), but when given in combination, the lowering effect was reduced[44]. Presenting results contrary to the above evidence[37, 44, 49, 50], analysis from the other studies which assessed anthropometric status observed no significant differences between intervention and control groups on BMI/BAZ[34, 36, 39, 42, 44] or MUAC[39] even after three years of school nutrition intervention[34].

b. Nutrition-related KAB

i. Nutrition Knowledge: All the three studies that reported on nutrition knowledge[34, 45, 48] gave evidence in favour of the positive impact of nutrition education on nutrition knowledge. For instance, De Villiers et al.[34] found intervention significance ($p = 0.02$) in an intervention group, both at first and second follow-ups ($p = 0.031$). In another study aimed at improving dietary intake patterns, correlations linked protein intake to knowledge of proteins, and vitamin C intake to knowledge of fruits and vegetables[45]. The nutrition knowledge of the intervention participants improved significantly ($p < 0.001$) from a total of 45.4% to 58.8% for all nutrition knowledge questions. Even a long-term measurement still reflected retention of nutrition knowledge, except for topics related to variety in a diet (23.8%), serving size of specific foods (34.9%), required daily allowance of specific foods (42.9%), and fat intake and classification

(42.9%). The results[45] must be interpreted with caution, however, since there was a significant dropout rate (43%) in this study making the results difficult to generalize. After investigating the effect of school nutrition education program on nutrition knowledge, Ebo's study[48] corroborated the evidence presented above. They also observed greater increase in nutrition knowledge ($p = 0.001$) for the intervention group. Regarding the impact of nutrition education on nutrition knowledge, the evidence was gathered from 650 intervention and 620 control participants from 21 different schools (table 4 of the appendix).

ii. Nutrition behaviour: Of the seven studies[34, 42, 43, 45-48] on this outcome, only two[47, 48] reported a positive impact of SBNIs on nutrition behaviour. Improvement in nutrition behaviour such as less sugar intake or more consumption of fruits and vegetables were primary measures in studies that assessed this outcome. Results from one of the nutrition education programmes suggested that nutrition behaviour did not change significantly after 9 weeks of intervention; legumes, fruits and vegetable intake remained low while refined sugars and fat were still consumed among the intervention group although mean intake for protein improved significantly[45]. Dietary intake analysis by Van der Hoeven et al.[43] of the efficacy of green leafy vegetable consumption on micronutrient status also showed no significant differences in energy intake at any of the follow-ups. The median energy intake was 7291 (5768-9960) kJ and 6493 (5258-8457) kJ in the intervention and in the control groups respectively. Although their 'HealthKick' was able to improve nutrition knowledge and self-efficacy significantly, it also had little impact on nutrition behaviour[34].

It appears, however, that theory-based and contextually appropriate school health promotion intervention may improve nutrition behaviours. Participants in a cognitive-behavioural nutrition intervention were significantly more likely to have met 5-a-day fruit and vegetable guidelines compared to HIV/STD risk reduction intervention participants in a control group (odds ratio =1.30, $p = 0.008$)[47]. They reported eating approximately 0.54 more servings of fruit ($p < 0.05$) and 0.77 more servings of vegetables ($p < 0.05$) than the controls after 12 months. The estimated effect sizes were 0.19 and 0.24 for fruit and vegetables, respectively[47]. After introducing an orange-fleshed sweet potato meal rich in vitamin A on five occasions for four weeks to 3rd and 4th grade intervention participants from 12 schools, their study demonstrated that specific goal-setting may help promote nutrition behaviour change[46]. Thus, directing children to state their intentions to eat a meal could increase the actual proportion of this meal consumed. Besides, the effect on a child's capability to make changes to their diet (self-efficacy) was found to be significant in a nutrition and physical activity intervention that sought to determine whether nutrition KAB improved after three years[34]. In fact, the study that presented the most favourable results to show evidence of effectiveness of school nutrition education on nutrition behaviour was Ebo's study[48]. They found a significant change in compliance in meeting a dietary guideline as well as in meeting a food pyramid's recommendations (p =0.001). This evidence must also be interpreted with caution, since the methodological rigour of the paper was rated as *'weak'*. So far, the evidence gathered on this outcome point to the conclusion that SBNIs do not necessarily influence nutrition behaviour positively.

c. Biochemical outcomes

The four studies on the BeForMi project included in this review[39, 44, 49, 50] assessed changes in several micronutrient status indicators, including haemoglobin (Hb), iron, serum retinol (vitamin A_1), plasma vitamin B-12, riboflavin and serum zinc. Kugo et al.[39] tested the efficacy of grounded dried carica papaya seed mixed with maize porridge on malnutrition and deworming. Their results indicated that a 300ml maize BeForMi, which contained 10g of the papaya seed increased Hb counts of the intervention group (11.5 g/dL to 13.5g/dL, p = 0.001). There was also a significant reduction of Ascaris lumbricoides (large round worm) egg count by 63% (mean 209.7epg to 75.7, p = 0.002) and Tinea capitis/ringworm infestation (from 54.4 to 34%, p = 0.002) after two months in the intervention group compared with the control that received a one-time 400mg dosage of albendazole, which is conventionally used for deworming. Evidence from the other food supplementation studies also showed that a BeForMi significantly increased Hb concentration, iron status indicators (serum ferritin and zinc protoporphyrin) concentrations and vitamin A status[44]. Using binary logistic regression, controlling for age, sex and baseline iron deficiency status, they demonstrated that their BeForMi significantly decreased the odd ratio for iron deficiency (OR 0.20; 95% CI 0.07, 0.53). The prevalence of iron deficiency significantly decreased from 29.2 to 5·5% in children who received the BeForMi[44].

Presenting further evidence, Abrams et al.[50] demonstrated that fruit-flavoured BeForMi with 419 kJ/240mL blend of 12 micronutrients significantly improved hematologic measures. Iron and vitamin B status were also significantly better and serum zinc significantly higher at endpoint in the intervention group. The last BeForMi study also presented similar results. Thus, data from a double-blind placebo efficacy trial of an orange-flavoured BeForMi indicated that among children with anaemia (Hb < 110g/L) at baseline, there was a significantly larger increase in Hb concentration among participants in the intervention group than those in the control (+9.2 and +0.2 g/L respectively). In addition, the prevalence of children with vitamin A deficiency dropped from 21.4% to 11.3% compared with the nonfortified group (20.6% to 19.7%)[(50)].

Apart from the BeForMi studies, other SBNIs have presented similar evidence that food supplementation can improve micronutrient status. To assess the impact of Red Palm Oil (RPO) on vitamin A status, 15ml RPO was added to school lunch in two test zones. Using High Performance Liquid Chromatography to assess retinol levels, vitamin A status was found to have improved significantly in the RPO group, just as in a positive control that received a single vitamin A capsule of 60mg (0.77± 0.28 to 0.98 ± 0.33 µmol/L). The observed intervention effect was more significant in the RPO group (0.82 ± 0.30 µmol/L to 0.98 ±0.33µmol/L) than in a negative control consuming the regular school lunch without RPO ($p = 0.001$). The efficacy of RPO in addressing vitamin A deficiency was again observed to be more significant in another test zone of the same study, where serum retinol levels increased from 0.77 ± 0.37µmol/L at baseline to 1.07 ± 0.40 µmol/L one year later ($p < 0.001$)[(36)]. Further evidence showed that biscuit with RPO as a vitamin A fortificant can also be as effective as biscuit with synthetic β-carotene in improving vitamin A status[(42)]. The estimated treatment effect for the synthetic β-carotene biscuit was 2.88 µg/dl (95% CI 1.75 - 4.00) and that of the RPO biscuit was 2.26 µg/dl (95% CI 1.14 - 3.37). A related study also found a significant between-group treatment effect on vitamin A status, Hb, iron and urinary iodine in favour of participants who received biscuits fortified with micronutrients[(37)].

While it appears that green leafy vegetables such as Amaranthus cruentus, Cleome gynandra, Cucurbita maxima and Vigna unguiculate added to a school meal may help address vitamin A deficiency, their effects on other micronutrients have been unclear[(43)]. Although a green-leafy vegetable dish contributed 11.6-15.8mg iron and 1.4-3.7mg zinc, no significant intervention effect was found for the dish on micronutrient status. It is important to add that two of the five SBNIs among the 30 potentially eligible articles which were excluded in the review process for not meeting the age inclusion criteria[(59, 60)] had however found that intake of dark green, leafy vegetables with fat, significantly increased retinol levels (vitamin A) ($p < 0.05$) among intervention participants[(59)], and sun-dried cowpeas with amaranth leaves recipe also enhanced vitamin A status and Hb concentration[(60)] among preschool children. In sum, our analysis of the biochemical indicators as study outcomes showed that all the studies on BeForMi and other SBNIs included in this review have presented evidence of the effectiveness of SBNIs in improving the micronutrient status of school children and adolescents.

d. Psychosocial outcomes

Our analysis also involved assessment of the relationship between SBNIs and cognitive performance. Cognitive outcomes comprised: general intelligence (two studies(42, 44)), change in arithmetic test scores (three studies(37, 42, 44)) and verbal comprehension tests involving reading/spelling (three studies(37, 42, 44)). Findings of Whaley et al.(42) showed that supplementation with animal source food plays a key role in the optimal cognitive performance of children. Using the Raven's Coloured Progressive Matrices to measure general intelligence, they found a "most striking" (sic) significant impact [p = 0.01] of supplementation of a staple diet with meat on general intelligence among Grade One intervention participants, compared with a control after 21 months. Significant group differences were also observed in arithmetic test scores on an adapted version of the Wechsler Intelligence Scales for Children-Revised. However, the effects were neither equivalent across all domains of cognitive functioning, nor did different forms of animal source foods produce the same benefits. The study showed no significant difference in verbal meaning test scores(42).

Other findings showed that a BeForMi had beneficial effects on cognitive test scores(44). A BeForMi improved general intelligence (intervention effect: 0·76; 95% CI 0·10, 1·42) on the Kaufman Assessment Battery for Children version II (KABC-II) test and verbal meaning test scores (1·00; 95% CI 0·01, 2·00) on adapted version of the Hopkins Verbal Learning Test. Specifically, there was improvement in planning abilities, number recall, word order, short term memory recall, story completion and ability to discriminate among words in a familiar setting(44). Further evidence confirmed these findings; biscuits fortified with micro-nutrients (not a BeForMi) resulted in a significant between-group treatment effect in cognitive function tasks such as digit copying, counting letters, reading numbers, counting backwards and verbal fluency(37). In sum, all three studies of SBNIs on cognitive performance found a significant positive impact(37, 42, 44). Due to differences in data collection methods and measurements, meta-analysis was not feasible in this study.

DISCUSSION

This is the first systematic review of RCTs and controlled-before-and-after studies to assess the effectiveness of school-based nutrition interventions (SBNIs) among school children and adolescents in SSA. A total of 14 studies met our inclusion criteria. Duration and complexity of SBNIs in SSA over the past two decades have varied. With regard to the impact of SBNIs on micronutrient status, studies on beverages fortified with micronutrients (BeForMi)[39, 44, 49, 50], and other SBNIs on food supplementation/fortification[36-38, 43] involving 1699 intervention participants, presented evidence of effectiveness of SBNIs in improving child micronutrient status. There is sufficient evidence to confirm that food fortification can play a vital role in reducing micronutrient deficiencies. In addition, all studies that assessed cognitive outcomes[37, 42, 44], involving a total of 738 and 443 intervention and control participants respectively from 16 different schools, showed effectiveness of SBNIs in improving cognitive performance. More specifically, food supplementation with animal source food[42], or red palm oil[36, 38] or micronutrients[44] significantly improved general intelligence, verbal learning and arithmetic performance of school children and adolescents. While few nutrition interventions have used comprehensive neuropsychological tests, results from previous systematic reviews corroborate the evidence from our review on assessments of cognitive performance outcome[12, 33]. For instance, Kristjansson et al.[33] noted in their review that early micronutrient deficiencies can negatively affect physical, mental, and social aspects of child health.

Of the 14 included studies, only two[49, 50] observed intervention effect on anthropometry in favour of intervention groups. Thus, although there was evidence to show that SBNIs can have a positive impact on anthropometric status[49, 50], the majority of studies included in our analysis found no intervention effect[34, 36, 37, 39, 42, 44]. Specifically, regarding intervention effects on BMI/BAZ, six[34, 36, 37, 39, 42, 44] out of nine studies which reported on this outcome [34, 36-39, 43, 44, 49, 50] found that SBNIs had no significant effect on BMI. This finding is consistent with a previous review of diet interventions on weight status, which found that interventions did not have a significant effect on BMI outcomes[31]. On the contrary, of the two studies in the current review that reported an effect on anthropometry, Ash et al.[49] observed significant differences between groups for all anthropometric measures; the intervention group gained 0.55kg more weight, 0.57cm more height, and 0.32 more BMI units. Similarly, Abrams and colleagues[50] observed significant change in weight, WAZ, BMI and MUAC, for the intervention group. Regarding intervention effect on height status/HAZ, four studies[36, 37, 42, 44] reported no intervention effect. The inconclusive evidence of SBNIs impact on anthropometry reflects evidence from prior reviews[21, 23, 31, 33]. In their Cochrane systematic review and meta-analysis, Kristjansson et al.[33] found significant effects of school feeding on weight gain (kg) in lower-income countries but mixed effects in higher income countries. For height gain (cm), results from lower income countries were mixed, but in higher income countries, results were moderate and positive. Further evidence from subgroup analyses indicated that in lower income countries, height gain was significantly greater for younger children than for mixed age groups[33]. In another meta-analysis on physical activity and nutrition outcomes, the evidence indicated that interventions showed an average reduction in BMI of 0.11 kg/m^2, yet, the only nutrition study included in the review did not show any intervention effect on BMI[23]. As has been noted in previous reviews, the mixed evidence of intervention effect on anthropometry may be attributed to baseline malnutrition status or to the short duration of many of the interventions[18, 33]. Thus, we might expect to see effects on outcomes such as weight gain even with shorter study durations, and on height gain with longer durations[33].

Regarding nutrition behaviour, our analysis suggests that nutrition education may have little impact on nutrition behaviour[34, 43, 45]. but can improve nutrition knowledge significantly[34, 45, 48]. Thus, even though there was an improvement in nutrition knowledge, results from other included studies [34, 42, 43, 45] indicated that SBNIs could not change dietary intake patterns of participants, and very little variety occurred in diet choices. However, in a health promotion intervention aimed at encouraging health behaviours, the intervention increased fruit and vegetable consumption of adolescents by 1.3 servings per day, compared with the control group[47], while specific goal-setting also promoted nutrition behaviour change. Similarly, Ebo et al.[48] observed that school nutrition education program improved nutrition behaviour. Our evidence on nutrition behaviour outcome is inconsistent with results of other reviews, which observed significant improvement in nutrition behaviour outcomes[16, 30], however it is consistent with results of other metanalyses which observed moderate improvement in nutrition behaviour[21, 23, 32]. Even if potential gains appear modest due to small effect size, small intervention effects scaled up to large population can produce large public health benefits[23]. Evidence from prior studies suggest that although nutrition knowledge may exist, the level of poverty, lack of influence that children have on their food choices[45], and food poverty, and accessibility could make a complete change to healthier diets somehow difficult[58, 64, 65]. In sum, a possible explanation for the inconclusive results regarding intervention effectiveness on nutrition behaviour and anthropometry might be a duration factor as well as the complex nature of eating behaviour, along with limited statistical power[6, 21]. Nutrition behaviour is complex, and it may take time to change dietary habits.

Quality of the evidence

Risks for participants receiving the control intervention or adverse outcomes were generally not reported. In addition, none of the studies explicitly indicated the percentage of relevant confounders which were controlled (either in the design or analysis). As stated earlier, since these were public health and health promotion interventions, total blinding was impossible in many of the studies. In addition, few of the studies discussed existing school nutrition policies, or direct parental/community involvement in the development and implementation of the SBNIs[34, 39, 43, 59]. Notwithstanding the above limitations, food supplementation/fortification was generally described as very effective and free of adverse effects. Secondly, all included studies had comparators since they were either controlled before-and-after studies or RCTs. Thirdly, all the 14 studies were rated as *'strong'* on the *'data collection method'* criterion on the EPHPP risk of bias assessment tool (table 3 of appendix). This indicated that the data collection tools employed by the primary studies were shown to be both valid and reliable. Moreover, three of the studies[39, 44, 49] employed double blinding while the methodological quality of 10 of them (70.4%), were rated as "Strong". This makes the risk of bias across these studies low, hence their evidence can be said to be more reliable.

Implications for health practice, policy and future research

To contextualize these findings, it is important that results from this review be read alongside evaluations of SBNIs from other regional contexts which employed different evaluations of study designs other than RCTs or controlled before and after studies. To address the high incidence of micronutrient deficiencies in LMICs and/or the high incidence of anaemia in SSA in particular[8], the WHO and health professionals may have to intensify food supplementation strategies currently available to school children in LMICs. Globally, it is important that in countries where schools provide meals to school children, such meals should be supplemented with vital micronutrients or animal source food to help prevent the double burden of malnutrition. Food and drink fortification with appropriate micronutrients may have double benefits of improving both cognitive performance and nutrition status of school children. In addition, our findings imply that to effectively design SBNIs in the future, policy makers in the education sector planning may need to consider enhancing formal school curricula to include nutrition education since it can positively improve nutrition knowledge.

We recommend that future research should consider investigating the true impact that school nutrition programs may have on anthropometry and nutrition behaviour, focusing on whether program intensity and/or duration play any significant role. Specifically future research must help to find out the impact that nutrition education has on nutrition behaviour since current results on their potential impact are inconclusive. Indeed, the existence of few RCTs and controlled before and after studies of SBNIs in SSA indicates that there might be insufficient evidence from high quality and analytical school nutrition studies in SSA, and in LMICs in general. This view has also recently [2019] been expressed in a systematic review of food environment research in LMICs(66). This is a challenge, suggesting that there is an urgent need to improve research designs and methods to better understand the effectiveness of public health nutrition programs in LMICs(66). The implication is that public health researchers and health professionals need to improve the quality of not only school food environment research but that of the community and national nutrition research. Doing so will undoubtedly be crucial to the design of effective interventions to improve public health nutrition globally.

Limitations

The review process was presented with some methodological challenges. We included only studies published in English and we also included in our analysis one study with 'weak' methodological rigour. Unlike clinical control trials which present more homogenous populations, public health interventions display more heterogeneity. Consequently, the variability among the included studies limited the possibility of meta-analysis on the effect of each factor on child nutrition status. Our reason was that since the factors were measured differently in each study, reporting an estimate for the pool effect would misrepresent the impact of the factors on child nutrition. There was also the possibility of publication bias in the primary studies: studies showing 'negative' results are less likely to be written up and submitted, and less likely to be published. Methodological strengths of this review were the use of the PRISMA guidelines(35) in our reporting, as well as the use of the EPHPP tool(41) to assess the methodological rigour of included studies. This form of assessment has a proven content and construct validity. Our search from more than seven highly recognised electronic databases presents a high level of methodological rigour to the review process. It is also important to note that our review is the first systematic review of RCTs and controlled-before-and after studies to assess the effectiveness of SBNIs among school children and adolescents in SSA. Therefore, it provides the best summary to date of the likely average effect of SBNIs on nutrition status of school children and adolescents in the sub-region.

Conclusions

When addressing child malnutrition, evidence from RCTs and controlled-before-and-after studies of school nutrition interventions in SSA generally confirm the view that the school setting is a very important place to start from. There is strong evidence that supports the positive impact that SBNIs can have on cognitive abilities, nutrition knowledge and improved micronutrient status of school children. There are few existing studies of SBNIs in SSA, however, evidence from such studies supports the view that food supplementation is very effective in addressing micronutrient deficiencies in school children and can improve their overall nutrition status. Secondly, nutrition education may enhance nutrition knowledge, but this may not necessarily translate into healthy nutrition behaviour. This could mean that nutrition knowledge simply has little impact without a facilitating environment. In sum, there is strong evidence to show that SBNIs can positively enhance nutrition status of school-aged children and adolescents. Some evidence also exists to show that SBNIs may positively enhance growth and cognitive development. The key conclusion is that there is enough evidence of promise to warrant further trials in these areas.

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Appendix

Table 1: The terms used in the electronic bibliographic search of the school nutrition review in SSA[1]

• School nutrition OR • School-based nutrition OR • School nutrition policy OR • School nutrition intervention* OR • School feeding OR • School feeding program* OR • School food OR • School canteen OR • School cooking OR • School breakfast OR • School lunch OR • School diet* OR • school eating OR • school nutrition education	**AND**	• Sub-Saharan Africa OR • Saharan Africa OR • Sub-Sahara OR • Africa OR • Sahel region OR • West Africa OR • East Africa OR • Southern Africa OR • Central Africa OR • SSA (country list): South Sudan, Angola, Burundi, Congo, Rwanda, Sao Tome, Cameroon/Cameroun, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, Djibouti, Eritrea, Ethiopia, Somalia, Kenya, Tanzania, Uganda, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Zambia, Zimbabwe, Sudan, Mauritania, Gambia, Ghana, Guinea, Liberia, Nigeria, Sierra Leone, Benin, Burkina Faso, Ivory Coast/Cote D'voire, Guinea Bissau, Mali, Niger, Senegal, Togo, Cape Verde

[1] Sub-Saharan Africa

Table 2: Characteristics of included studies

Author/Year/ Country	Aim of study	Design	Duration	Participants & Intervention	Measures	Findings
Kugo et al., 2018(39) Kenya	Test alternative Mass Drug Administration approach which integrates deworming into school meals while addressing malnutrition	Placebo-controlled RCT[2]	2 mo[3]	N[4] =324 school children; mean age = 8.7yr[5], males = 51.7%; mean weight =24.9 kg[6]; mean height =126.4cm[7] Participants either received 400mg Albendazole, n =119; Maize meal porridge with pawpaw seeds, n=103; or Maize meal porridge without pawpaw seeds, n =102. Children in the albendazole group also received plain maize meal porridge without pawpaw seed. Each child received 300ml of the porridge every day, constituting a dose of 10g of carica papaya seeds per child per/d[8]	parasitology in faeces, haemoglobin concentration and anthropometry	Papaya seed fortified porridge had a significant positive effect on children's fungal infections and better nutritional outcome
De Villiers et al., 2016(34) South Africa	Determine whether nutrition knowledge, self-efficacy and eating behaviour improved after a 'Health Kick' intervention	Cluster RCT	3 yr	N =998, grade 4 learners, mean age = 9.9yr, 8 schools in the intervention group n=500 and 8 schools in the control group (n=498) Educators identified their own school health priorities and ways to address them. Schools were provided with nutrition resources, including curriculum guidelines and the South African food-based dietary guidelines. Children completed a questionnaire comprising nutrition knowledge, self-efficacy and behavioural items.	nutrition knowledge, attitude and self-efficacy, BMI[9]	Intervention showed significant improvement in nutrition knowledge, self- efficacy but not in nutrition behaviour change
Van der Hoeven et al., 2015(43) South Africa	Assess the effect of African leafy vegetable (ALV) consumption on Fe, Zn and vitamin A status	Parallel group RCT	3 mo	N =239 school children,6–12yr, response rate =71.5% Participants received either a 300g cooked ALV dish and school meal starch (n=86) or normal school meal (n=81) 5x/wk[10] for 3mo. ALV in the dish consisted of amaranthus cruentus (at least 80%) and the remainder of Cleome gynandra, Cucurbita maxima or Vigna unguiculata. Nutrient content and consumer acceptance of the ALV dish were also determined.	dietary intake assessment with FFQ[11], anthropometry, biochemical indicators (fe, zn or vitamin B deficiency)	ALVs were unable to improve micronutrient status.
Taljaard et al., 2013(44) South Africa	Investigate the effects of micronutrients and sugar, alone and in combination, in a beverage on growth and cognition	Double blind, 2x2 factorial R CT	8.5 mo	N= 414 schoolchildren, 6–11yr Participants consumed beverages containing (1) micronutrients with sugar, (2) micronutrients with a non-nutritive sweetener, (3) no micronutrients with sugar or (4) no micronutrients with a non-nutritive sweetener for 8·5mo.	biochemical indicators, anthropometry (2007 WHO references), cognition (KABC-II)[12] and the HVL[13]	Beverage fortified with micronutrients, positively affects school children's cognition.
Zeba et al., 2006(36)	Assess the impact on serum retinol (vitamin A) of adding red palm oil	pre-post-test at Kaya	12 mo	N=623; Kaya zone, n = 239 pupils, 15 intervention schools; Bogandé zone, n =384 pupils, 24 schoools; mean age at baseline 101-102mo	serum retinol test with High Performance	RPO as food supplement for vitamin A is highly

[2] Randomized Controlled Trial
[3] Months
[4] Sample size
[5] Years
[6] Kilogram
[7] Centimetres
[8] Day/days
[9] Body Mass Index
[10] Week
[11] Food Frequency Questionnaire
[12] Kaufman Assessment Battery for Children (KABC-II)
[13] Hopkins Verbal Learning test

Burkina Faso	(RPO) to school lunch in two test zones	RCT at Bogande		A 15ml RPO was added to school lunch 3x/wk in Kaya. In Bogandé, there were: 8 negative controls with only regular school lunch (G1); 8 positive controls where participants received a single 60mg vitamin A capsule at the end of the school year (G2); and 8 schools with RPO through the school year (G3). Serum retinol was measured at baseline and exactly 12mo later.	Liquid Chromatography, anthropometry	effective in the reduction of vitamin A deficiency
Oosthuizen et al., 2011(45) South Africa	Improve dietary intake patterns and food choices	CBA[14]	9 wk[15]	N = 172 grade 7students, 9-13yr, 2 schools Participants were grouped into experimental group where nutrition education programme was implemented over one school term (n=81), and a control (n =91). Testing of nutrition knowledge, using a validated 24-hour recall questionnaire, occurred pre-and post-intervention, and in the long term, with the experimental group only.	dietary intake patterns, nutrition knowledge	Although nutrition knowledge improved, it did not reflect in dietary intake patterns; intake of fruits and vegetables were low.
Abrams et al., 2003(50) Botswana	Examine efficacy of a micronutrient fortified beverage in improving nutritional status	CBA	8 wk	N=263 pupils, 6-11yr Participants were given seven 419 kJ/240ml servings weekly of either fruit-flavored beverage [EXP, n=145] fortified with 12 micronutrients or a control, an isoenergetic placebo drink [CON[16], n=118] for 8wk. The CON group received the same beverage without micronutrients.	growth, hematologic (Hb, retinol, ferritin, vitamin B-12, folate and riboflavin status)	Micronutrient-fortified beverage can significantly prevent micronutrient deficiencies
Ash et al., 2003(49) Tanzania	Describe the main effects of orange-flavoured micronutrient-fortified beverage on anaemia, iron & vitamin A status, and growth	Double-blind RCT	6 mo	N= 774 pupils, 6 rural primary schools, 6-11y Children were assigned to receive one serving of fortified beverage or an unfortified beverage 5d/wk. Fortified and unfortified sachets had a blue or green label for identification and contained identical powder which provided 90 kcal in each 25g sachet. The content of a sachet was mixed with 250 mL boiled water to make a pleasant-tasting, orange-flavoured beverage.	Growth (anthropometry), biochemical (hematologic, anaemia, vitamin A, iron status)	A fortified beverage improved hematologic, anthropometric measures and significantly lowered prevalence of anaemia and vitamin A deficiency
Ebo & Boye, 2006(48) Nigeria	Investigate the effect of a school-based nutrition education program on nutrition knowledge and food choices	CBA	3 wk	N =197 sixth graders, 6 urban public schools, (CON =102, and EXP = 95) The control group received no nutrition education while the experimental group received 40 minutes of nutrition education, 4d/wk for 3wk. Nutrition knowledge scores and a 3-day food records were collected at pre-and-post intervention periods.	nutrition knowledge, healthy food choices	Nutrition education improved nutrition knowledge and healthy food choices.
Jemmot et al., 2011(47) South Africa	Test efficacy of school-based cognitive behavioural health promotion (HP) intervention to increase fruit and vegetable KAB[17].	Cluster RCT	12 mo	N =1057 grade 6 learners,18 schools, 9-18 yr, mean age = 12.4yr One school in each pair of 9 matched schools was randomized to either a cognitive-behavioural HP intervention or to a control group of HIV/STD risk-reduction intervention. The HP intervention aimed to encourage KAB, to practice healthful behaviours, including fruit and vegetable consumption, nutritional value of variety of foods and their health effects.	fruit & vegetable consumption with FFQ	Cognitive-behavioural intervention can increase self-reported HP behaviours, (especially, fruit & vegetable consumption)
Lagerkvist et al., 2018(46) Nigeria	Analyse how specific goal setting promoted dietary behaviour change in consumption of pro-vitamin A rich orange-	Cluster RCT	4 wk	N= 556 3rd & 4th grade pupils, 7–12yr (274 females, 282 males), 12 schools A meal based on OFSP, rich in pro-vitamin A, was introduced as a complement to an existing school meal. Three days before the study, nutrition education was held in each classroom for 1hr[18]. Teachers were trained to inform participants about: (a) the 5 food groups, their main nutrients and functions; (b) importance of a	baseline intentions, anticipated feelings, food intake focusing on the number of times	Type of incentives matters, not the emotional effects after eating. Emotions are more related to the eating situation than

[14] Controlled-before- and-after study
[15] Weeks
[16] Control group
[17] Knowledge, Attitude and Behaviour
[18] Hour

	fleshed sweet potato (OFSP) meal			balanced diet; (c) the food pyramid; (d) healthy food choices; and (e) incorporating OFSP in foods. Participants were called by name to either receive their own goal card (reminder treatment) or no-reminder treatment card before eating.	main food groups were consumed per d/wk	to the type of goals set for the behaviour.
Whaley et al., 2003[42] Kenya	Test the impact of 3 different diets/ animal source food on cognitive development of school children.	Cluster RCT	21 mo	N=555 grade 1 children, 12 schools; mean age-7.63yr; males-52% The 12 schools were randomized into one of 4 feeding interventions: 3 of which received a fortified local staple-based snack (Githeri meal) that provided 240 kcal in the first school year and 313 kcal for the remainder of study period. The groups—designated as (i) Meat-Githeri n=134, (ii) Milk-Githeri, n=144, and iii) Energy-Githeri, n=148 and Control, n=129. Cognitive tests were administered at baseline and during every other term of feeding.	cognitive assessments, anthropometry, consumption of the supplemental food, family measures, SES, School attendance	Supplementation with animal source food plays a key role in the cognitive development of school children.
Van Stuijvenberg et al.2001[38] South Africa	Determine the effect of biscuit with red palm oil as a source of β-carotene on vitamin A status and to compare with the effect of biscuit with β-carotene from synthetic source	Single blind RCT	3 mo	N= 400, aged 5-11y Participants were randomly assigned to: (i) A control group receiving a placebo biscuit without β-carotene, n=14; (ii) a biscuit with synthetic β-carotene as a vitamin A forticant (SB), n=146; (iii) a biscuit with refined red palm oil (RPO) as a source of β-carotene (PB), n=145; SB and PB supplied 30% of the required daily allowance for vitamin A per serving of three biscuits. Vitamin A status was assessed at baseline and after 3mo. The biscuits of all 3 groups were similar in macronutrient composition, in taste and appearance.	anthropometry, full blood count; blood (5ml) was obtained by venepuncture, Serum retinol was determined by a HPLC method	Biscuit with RPO is as effective as a biscuit with synthetic β-carotene.
Van Stuijvenberg et al.1999[37] South Africa	Determine the effect of micronutrient-fortified biscuits on the micronutrient status of primary school children	Single blind RCT	12 mo	N=228, aged 6–11y; grades 1-5 Micronutrient status was assessed in school children before and after consumption of biscuits (fortified with iron, iodine, and β-carotene, n =115). It was compared with a control (n =113) who consumed nonfortified biscuits. The shortbread biscuits were designed to provide 50% of the recommended dietary allowances of iron (5 mg ferrous fumarate), iodine (60 mg potassium iodate), and β-carotene (2.1 mg).	anthropometry, cognitive function, growth and morbidity assessed as secondary outcomes	Fortification of biscuits with Iron, iodine and B-carotene resulted in a significant improvement in micronutrient and anthropometric status.

Table 3: Ratings of included studies on the EPHPP risk of bias assessment tool

Study	Kugo et al., 2018[39]	De Villiers et al., 2016[34]	Van der Hoeven et al., 2015[43]	Taljaard et al., 2013[44]	Zeba et al., 2006[36]	Oosthuizen et al., 2011[45]	Abrams et al., 2003[50]	Ash et al., 2003[49]
• **Selection bias** • Are individuals selected to participate in study likely to be representative of target population? • What % of selected individuals agreed to participate?	Very likely	Very likely	Somewhat likely	Somewhat likely	Very likely	Very likely	Somewhat likely	somewhat likely
• **Study design** • Was the study described as randomized? • If yes, was the method of randomization described? • If yes, was the method appropriate?	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes No -	No - -	Yes Yes Yes
• **Confounders** • Were there important differences between groups prior to the intervention? • If yes, indicate the % of relevant confounders that were controlled (either in the design or analysis)?	No Can't tell	No Can't tell	No Can't tell	No Can't tell	No Can't tell	Can't tell Can't tell	No Can't tell	No Can't tell
• **Blinding** • Was (were) the outcome assessor(s) aware of intervention or exposure status of participants? • Were the study participants aware of the research question?	Can't tell No	Can't tell Can't tell	No No	No No	No No	Can't tell No	No No	No No
• **Data collection method** • Were data collection tools shown to be valid? • Were data collection tools shown to be reliable?	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
• **Withdrawals and dropouts** • Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group? • Indicate % of participants completing the study. (If the % differs by groups record the lowest).	Yes 75%	No No	Yes Yes	Yes No	Yes No	Yes 43%	Yes 84.5%	Yes 93%
Global rating/ overall score for this paper	**Strong**	**Moderate**	**Strong**	**Strong**	**Strong**	**Moderate**	**Strong**	**Strong**

Study	Ebo & Boye, 2006[48]	Jemmot et al., 2011[47]	Lagerkvist et al., 2018[46]	Whaley et al., 2003[42]	Stuijvenberg et al., 2001[38]	Stuijvenberg et al., 1999[37]		
• **Selection bias** • Are individuals selected to participate in study likely to be representative of target population? • What % of selected individuals agreed to participate?	Somewhat likely	Very likely	Very likely	Somewhat likely	Very likely	Very likely		
• **Study design** • Was the study described as randomized? • If yes, was the method of randomization described? • If yes, was the method appropriate?	No - -	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes		
• **Confounders** • Were there important differences between groups prior to the intervention? • If yes, indicate the % of relevant confounders that were controlled (either in the design or analysis)?	No Can't tell	No Can't tell	No Can't tell	No Can't tell	No Can't tell	Can't tell Can't tell		
• **Blinding** • Was (were) the outcome assessor(s) aware of intervention or exposure status of participants? • Were the study participants aware of the research question?	Can't tell Can't tell	No No	Can't tell No	Yes No	Yes No	Yes No		
• **Data collection method** • Were data collection tools shown to be valid? • Were data collection tools shown to be reliable?	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes		
• **Withdrawals and dropouts** • Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group? Indicate % of participants completing the study. (If the % differs by groups record the lowest).	Yes 100%	Yes 96.7%	Yes 86.5%	Yes _	Yes 91.5%	Yes 90.1%		
Global rating /overall rating for this paper	**Weak**	**Strong**	**Moderate**	**Strong**	**Strong**	**Strong**		

Table 4: Intervention focus on outcomes per the number of studies and corresponding participants.

Outcome	No. of studies	Intervention focus	Intervention Participants	Control Participants
Anthropometry	10	Deworming & malnutrition (1study), Nutrition KAB[19] (1), micronutrient status (2), growth & cognition (1), vitamin A status (2 studies), nutrition status (1), growth and micronutrient status (1), cognitive development (1),	2625	1952
Nutrition knowledge	3	Nutrition KAB (2 studies), Nutrition behaviour (1study),	650	620
Nutrition behaviour	6	Nutrition KAB (4 studies), micronutrient status (1), dietary behaviour (1)	2314	2279
Biochemical outcomes	8	Deworming & malnutrition (1), micronutrient status (2), growth and cognition (1), vitamin A status (2), nutrition status (1), growth & micronutrient status (1)	1699	1325
Cognitive outcomes	3	Micronutrient status (1), cognitive development (1), growth & cognition (1)	738	443

[19] Knowledge, Attitude and Behaviour