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Interventions To Manage Malnutrition Among Preschool Children (3-6 Years): A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Malnutrition among preschool children (ages 3–6 years) remains a global health issue, particularly in low- and middle-income countries. This age group is especially vulnerable due to their rapid growth and development, and effective interventions are crucial to mitigate the associated risks of stunting, wasting, and micronutrient deficiencies.

Objective: To systematically review and assess the effectiveness of various interventions aimed at managing malnutrition among preschool children aged 3–6 years.

Methods: This review adhered to PRISMA guidelines and was registered with PROSPERO. A comprehensive search was conducted across databases including PubMed, Cochrane and Scopus. Studies were included if they were randomized controlled trials or quasi-experimental studies published in English from January 2014 to February 2025, involving children aged 3–6 years diagnosed with malnutrition. Interventions evaluated included fortified foods, general nutritional supplementation, micronutrient supplementation, educational programs, and water and sanitation interventions. Risk of bias was assessed using the Cochrane Risk of Bias tool, and a qualitative synthesis was performed due to heterogeneity in outcomes and study designs.

Results: Fourteen RCTs involving approximately 10,386 children were included. Interventions such as iron-fortified complementary foods, oral nutritional supplements, and nutrition education demonstrated improvements in anthropometric measures (e.g., weight-for-age and height-for-age) and biochemical markers (e.g., hemoglobin, serum ferritin). However, pooled estimates from four studies revealed no statistically significant difference in weight (SMD = 0.24; 95% CI: -0.26 to 0.74) or height (SMD = 0.08; 95% CI: -0.18 to 0.35) between intervention and control groups, with substantial heterogeneity.

Conclusion: Multiple interventions, particularly those involving nutritional supplementation and fortification, show promise in managing malnutrition among preschool children. However, the effectiveness varies by context, highlighting the need for tailored strategies. Further high-quality research is needed to address gaps and inform scalable, context-sensitive public health policies

Keywords: *Malnutrition, Preschool children, Nutritional interventions, Supplementation, Fortification, Randomized controlled trials, 3-6 years*

1. INTRODUCTION

Malnutrition remains one of the most critical global health challenges, particularly in low- and middle-income countries, where it significantly impacts the health and development of children under five years of age. Preschool children (3-6 years) are particularly vulnerable, as this period is characterized by rapid physical, cognitive, and emotional growth. The consequences of malnutrition during this developmental phase can be devastating, leading to stunted growth, impaired cognitive function, weakened immune systems, and an increased risk of mortality from infectious diseases. According to the World Health Organization (WHO), malnutrition in children is responsible for nearly half of all deaths in children under the age of five globally (World Health Organization [WHO], 2023).

Malnutrition among preschool children is primarily categorized into undernutrition (including stunting, wasting, and being underweight), micronutrient deficiencies (such as iron, vitamin A, and zinc), and overnutrition, which may contribute to obesity and its associated non-communicable diseases (Sahu et al., 2015; Fouad et al., 2023. Gender inequality, education, poverty, sanitation and safe water access are some considerable socioeconomic factors to determine health outcomes in many developing and underdeveloped countries. These factors can directly impact the nutritional status of preschool children and contribute to the prevalence of malnutrition. Interventions addressing these social determinants are crucial in improving the overall health and well-being of children in these regions. (Muhammad and Aisha) Addressing these forms of malnutrition is essential not only for improving individual health outcomes but also for achieving broader public health goals, such as reducing poverty, improving educational outcomes, and enhancing productivity in adulthood (Bhutta et al., 2013).

Various interventions have been developed to manage malnutrition in young children, ranging from dietary supplementation and fortification to community-based nutrition programs and healthcare system improvements (Black et al., 2015). Despite the diversity of these interventions, the effectiveness and feasibility of specific approaches remain inconsistent across different settings. Randomized controlled trials (RCTs), considered the gold standard for evaluating the efficacy of health interventions, offer valuable insights into the strategies that can effectively address malnutrition in preschool children. However, the generalizability of RCT results may be limited by factors such as sample size, study duration, and participant characteristics. Therefore, a combination of RCTs and implementation research is necessary to determine the most appropriate and sustainable interventions for combating malnutrition in young children.

This systematic review aims to synthesize the existing evidence from RCTs on interventions designed to manage malnutrition among preschool children. By critically analyzing the data from various RCTs, this review will provide a comprehensive overview of the effectiveness of different strategies in addressing malnutrition. Ultimately, this synthesis will help inform policymakers and healthcare professionals on evidence-based approaches to combatting malnutrition in young children. By reviewing and analyzing the outcomes of these studies, we aim to identify the most effective strategies, barriers to implementation, and areas for future research. This review will also highlight any gaps in current research and suggest potential areas for further investigation to improve interventions for managing malnutrition in preschool children. Additionally, by synthesizing the data from multiple studies, we hope to provide a clearer understanding of the most successful approaches that can be implemented on a larger scale. Ultimately, the findings of this review will inform public health policy and programmatic efforts aimed at combating malnutrition and improving the nutritional status of preschool children worldwide. By identifying effective strategies and interventions, policymakers and program developers can better address the complex issue of malnutrition in this vulnerable population. Through a comprehensive analysis of existing literature, this review aims to contribute valuable insights that can guide future initiatives and ultimately lead to improved health outcomes for preschool children.

2. OBJECTIVES

To systematically review and assess the effectiveness of interventions aimed at managing malnutrition among preschool children (3-6 years).

Review question

What are the interventions designed to manage malnutrition among preschool children (3-6 years)?

Methods

This review adhered to the PRISMA guidelines for the systematic reviews. This review is registered in the PROSPERO registry (CRD420251022005).

The Population (P), Intervention (I), Comparator (C), Outcome (O) framework to identify the relevant studies.

Eligibility Criteria

Population: This review will include preschool children aged 3 to 6 years diagnosed with malnutrition (undernutrition). Studies that include any preschool children with stunting, muscle wasting was considered. Studies involving children outside 3-6 years were excluded. If there are any studies that include a wide range of children, in that case if adequate data was available for children aged 3-6 years only was included.

Interventions: Any intervention aimed at managing malnutrition, including nutritional supplementation, food-based interventions, educational programs, and health interventions. Studies focusing on medical management of malnutrition were excluded from this review.

Comparator: In this review interventions are compared with the standard care that is provided to improve malnutrition in children.

Outcome Measures: This review mainly focused on nutritional status (weight-for-age, height-for-age, BMI-for-age) of the children. Studies having outcomes on overweight will be excluded.

Study Design: To provide a higher level of evidence through this review, we included only Randomized controlled trials (RCTs) and quasi-experimental studies published between January 2014-February 28, 2025, are considered.

Language: Studies published in English language will be considered.

Searching for literature:

A comprehensive search was carried out in the databases including PubMed, Cochrane and Scopus. Initially the search terms were identified through the MeSh database and by refeering the relevant article keywords. The keywords formulated were "malnutrition", "undernutrition", "overnutrition", "preschool children", "3-6 years old", "toddlers", "intervention", "treatment", "supplementation", "nutrition education", "effectiveness" OR "impact". Further the relevant studies were also searched through the help of grey literature mainly through google scholar and clinical trial websites. Reference lists were searched to identify any missed article during the search. The detailed search strategy is provided in Appendix 1.

Study Selection

In this review we used Rayyan software to manage duplicate removal and screening of the articles. We followed two stage screening process to identify the relevant studies for this review. Two reviewers independently screened titles and abstracts of the identified studies. Further Full-text screening was conducted for articles that meet the inclusion criteria. Disagreements were resolved through discussion and by consulting a third reviewer.

Data Extraction

Data was extracted in MS-Excel using a standardized form that includes Study characteristics (author, year of publication, country, study design), Participant characteristics (age and gender), Intervention details (type, duration, dosage, frequency), Outcomes measured (growth parameters, nutritional status) and Results (effect size, statistical significance, and confidence intervals). Two reviewers independently extracted the data for this review. Further any conflicts were resolved through discussion.

Risk of Bias Assessment

The risk of bias in individual studies was assessed using Cochrane Risk of Bias Tool for RCTs. Bias domains include selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases. Two reviewers independently extracted the data for this review. Further any conflicts were resolved through discussion and contact with the third reviewer.

Data synthesis

The data was synthesized qualitatively due to the heterogeneity of the data to step into quantitative analysis.

3. RESULTS

Study selection

The search provided with a total of 884 hits PubMed (n=78), Cochrane Library (n=544) and Scopus (n=262). Further 191 duplicates were removed in the Rayyan software. A total of 693 studies underwent Title/Abstract screening and 607 were excluded. Later 86 studies were screened for Full-text and 72 were excluded due to different reasons including, wrong population (n=47), wrong outcome (n=18), wrong publication (n=7). The review included 14 RCT studies that met the inclusion criteria. Figure 1 describes the study selection process.

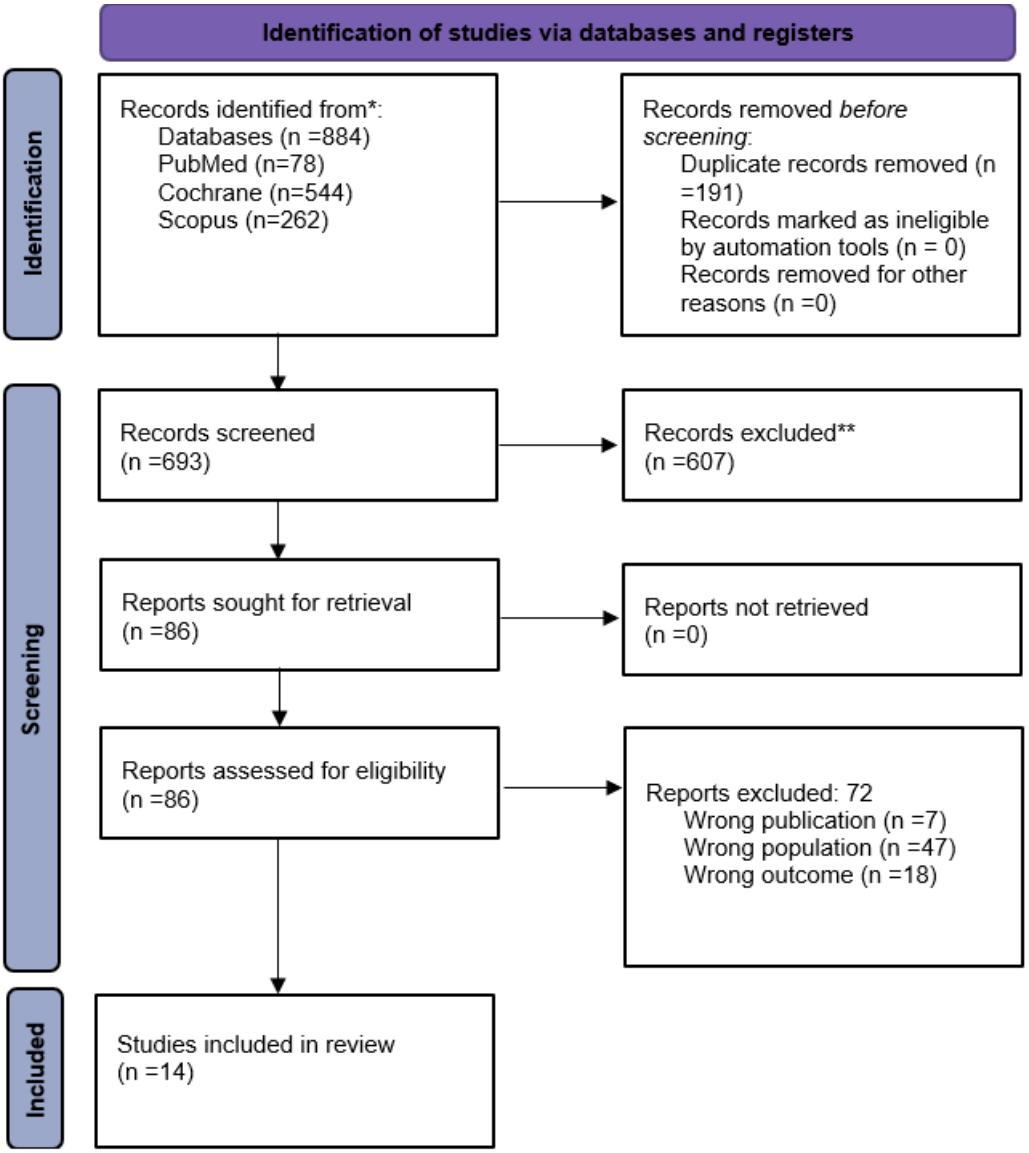

Figure 1: PRISMA flowchart diagram of study review process and selection

Quality assessment

The risk of bias was assessed for all 14 included randomized controlled trials using the Cochrane Risk of Bias Tool. Most studies showed low risk for random sequence generation, including those by Ekoe T (2020), Khadilkar A (2021), Brett N (2016), Sazawal (2018), Islam M (2013), Ansuya B (2023), Doocy S (2018), Leis A (2020), Chen K (2014), Basri H (2021), and Zavoshy R (2012), while Schneider N (2018) rated as unclear due to lack of detail. Allocation concealment was adequately reported in studies by Khadilkar A, Ekoe T, Chen K, Doocy S, and Sazawal, whereas others provided insufficient information. Blinding of participants and personnel was clearly implemented in six studies (Chen K, Brett N, Khadilkar A, Ekoe T, Sazawal, and Islam M), suggesting low risk of performance bias; the remaining studies, including Ansuya B, Doocy S, Basri H, Schneider N, and Zavoshy R, were rated as high or unclear risk. Similarly, blinding of outcome assessors was reported in Ekoe T, Chen K, Khadilkar A, Brett N, and Islam M, while other studies lacked such information. Incomplete outcome data were adequately addressed in 13 studies, with only Schneider N (2018) showing high attrition and rated high risk. Selective reporting was judged low risk in 11 studies (Ekoe T, Brett N, Khadilkar A, Islam M, Doocy S, Chen K), while Basri H, Schneider N, were rated unclear due to absence of protocol or inconsistent outcome reporting. Other potential sources of bias were generally low across studies, except for Schneider N, Basri H, and Zavoshy R, which raised concerns regarding funding or baseline imbalances. Overall, while the included RCTs were of moderate to high methodological quality, performance and detection biases were the most commonly observed limitations.

Characteristics of the included studies

This review included 14 randomized controlled trials that met the inclusion criteria. The studies were conducted across

various geographical regions, including Cameroon, Canada, China, Ethiopia, Pakistan, Nigeria, Indonesia, India, Iran, and Bangladesh, reflecting a diverse global distribution. The review focused on preschool children aged 3 to 6 years, although some studies included a slightly broader age range (18–59 months or 6–59 months), with subgroup data relevant to 3–6 years extracted where available. Most children were in the 3–5 years age range, aligning with the target population of this review. The total sample size across all included studies was approximately 10,386 preschool children.

The interventions varied widely and included micronutrient fortification (e.g., iron, vitamin D, zinc), oral nutritional supplements, home-based nutrition education, cooked meal programs, and sanitation and water treatment strategies. The duration of interventions ranged from 3 days to 15 months, with frequencies varying from daily to monthly, depending on the nature of the intervention. Outcome measures focused primarily on growth indicators such as weight-for-age, height-for-age, mid-upper arm circumference (MUAC), and biochemical markers like hemoglobin, serum ferritin, and zinc absorption, as well as functional outcomes including morbidity reduction, cognitive development, and recovery from malnutrition. A detailed description of each study's characteristics is presented in Table 1. The pooled effect estimates of the effect of interventions on height and weight of children are predicted in Figure 2 and 3.

Interventions to manage malnutrition among preschool children

Fortified Foods

Four studies Ekoe T (2020), Brett N (2016), Sazawal (2018), Islam M, 2013, explored the efficacy of food fortified with Iron, Vitamin D and Zinc respectively to manage malnutrition in preschool children. Ekoe 2020 showed that the Iron-fortified complementary food (IC) significantly improved hemoglobin, ferritin, serum iron, transferring saturation, and weight-for-age z-scores at 6 months compared to the control group. while brett N mentions that the serum 25(OH)D was higher in the EAR and RDA groups as compared to the control group. However, there was not much difference between the serum levels of EAR and RDA over 12 weeks. Sazawal showed that high zinc biofortified wheat flour imporved the morbidity of the preschoolers as compared to the low zinc wheat but there was no difference in the zinc levels between the two groups. islam M showed that the Fractional zinc absorption (FZA) was higher in the conventional rice as compared to the other sources.

-Nutritional Supplementation (General)

Four studies Khadilkar A,2021, Zavoshy R, 2012, Basri H, 2021, Udoh E, 202performed intervention based on nutritional supplementation through different supplementation products. A study by Khadilkar A,2021 showed that Oral Nutritional Supplement (ONS) improved the weight for age and height of the children when given for 3 months daily. Zavoshy R, 2012 proved that the intervention with cooked food reduced the prevalence of wasting in children. Basri H, 2021 showed that moringa extract intervention in pregnant women reduced the stunting in toddlers aged 36- 42 months.

Micronutrient Supplementation (Vitamin A,)

Chen K 2014 showed that vitamin A supplementation did not increase the iron levels in the body nor in the mobilization. However, in combination with iron supplementation it can cause an increase in storage iron as well as in crease on the body iron.

Educational Interventions

Leis A, 2020 and Ansuya B, 2023 highlighted the importance of health education and Ansuya,2023 showed that health education and introduction of protein rich recipe in mothers resulted in an increase in the weight of the children.

Water and Sanitation Interventions

Doocy S, 2018 showed the effectiveness of Aquatabs, ceramic filters, and P&G PoW in treating malnourishment in children, particularly diarrhea.

Pooled effect estimate of effect of interventions on weight among children

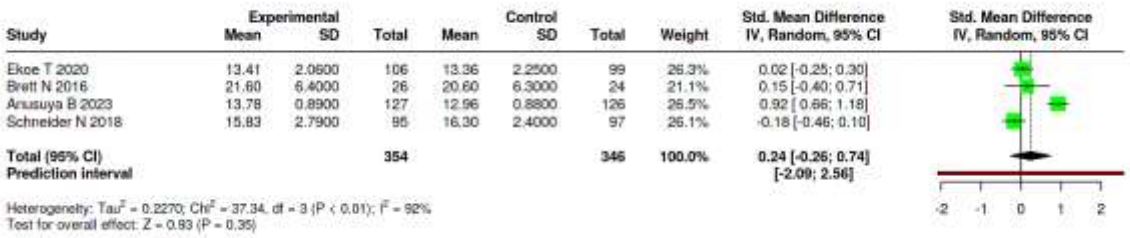

Figure 2: Pooled effect estimate of effect of interventions on weight among children

A total of 4 studies were included in the meta-analysis with a total of 354 subjects in the Intervention group and 346 subjects

in the Control group. Based on the analysis performed using random effects model with Inverse variance method to compare the standardized mean difference (SMD), there is no statistical difference between the two cohorts, the summarized standardized mean difference (SMD) is 0.24 with a 95% confidence interval of -0.26 - 0.74. The test for overall effect does not show a significant effect. A significant heterogeneity was detected (p<0.01), suggesting inconsistent effects in magnitude and/or direction. The I2 value indicates that 92% of the variability among studies arises from heterogeneity rather than random chance.

Pooled effect estimate of effect of interventions on height among children

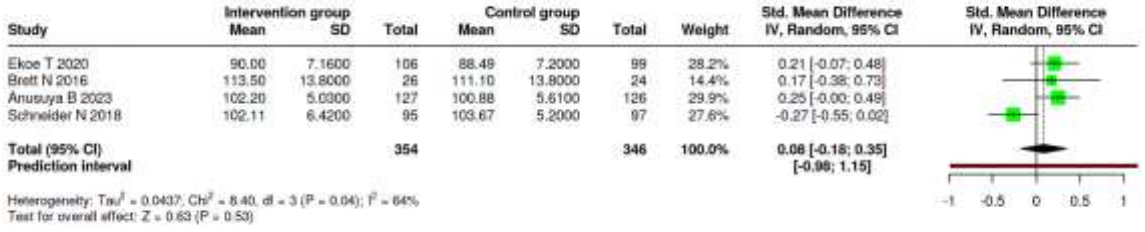

Figure 3: Pooled effect estimate of effect of interventions on height among children

To identify the pooled effect estimate of effect of intervention on height among children we included a total of 4 trials. A total of 354 subjects in the Intervention group and 346 subjects in the Control group were included. Based on the analysis performed using random effects model with Inverse variance method to compare the standardized mean difference (SMD), there is no statistical difference between the two cohorts, the summarized standardized mean difference (SMD) is 0.08 with a 95% confidence interval of -0.18 - 0.35. The test for overall effect does not show a significant effect. A significant heterogeneity was detected (p= 0.04), pointing at fluctuating effects in extent and/or direction. An I2 value of designates that 64% of the inconsistency among studies comes from heterogeneity rather than random chance.

4. DISCUSSION

This review aimed to assess the effectiveness of various interventions for managing malnutrition in preschool children aged 3 to 6 years, a critical period for growth and development. The included studies, conducted across a diverse range of settings, provide important insights into the potential strategies to address malnutrition globally. The sample size of approximately 10,386 preschool children adds strength to the findings, ensuring that the results are robust and applicable to different geographical regions and cultural contexts.

Micronutrient Fortification

-Iron Fortification

The study by Ekoe et al. (2020) showing that iron-fortified complementary foods significantly improved nutritional markers such as hemoglobin, serum ferritin, and weight-for-age z-scores aligns with other studies that have demonstrated the efficacy of iron fortification in improving iron status and growth in children. For instance, studies by Dewey et al. (2013) and Zimmermann et al. (2007) have shown that iron supplementation in complementary foods significantly reduces the risk of iron deficiency anemia (IDA) and supports improved growth. However, Brett et al. (2016), in their study on vitamin D, did not observe a significant difference between the EAR and RDA vitamin D dosages. This finding is similar to Rostami et al. (2016), who also reported no significant benefits from higher vitamin D dosages in improving bone health and growth in children, suggesting that vitamin D may not show linear dose-response effects in all populations.

-Zinc fortification

The study by Sazawal (2018) reported that high zinc biofortified wheat flour improved morbidity but showed no significant difference in zinc levels between intervention groups. This finding contrasts with earlier studies such as Michaelsen et al. (2009), which showed that zinc supplementation significantly improves both growth and immunity in children, suggesting that the bioavailability of zinc or the duration of intervention might have affected the outcomes in Sazawal's study. Prasad et al. (2018) found that zinc supplementation had a more pronounced effect on reducing morbidity and improving weight-for-age in children from low-income settings, indicating that the effectiveness of zinc supplementation may be context-dependent.

-Nutritional Supplementation

The studies by Khadilkar et al. (2021) and Zavoshy et al. (2012) on oral nutritional supplementation (ONS) and cooked food-based interventions highlight the positive impact of supplementation on weight-for-age and reducing the prevalence of wasting. These findings are in line with several other studies. For example, Mojaverian et al. (2014) and Berggren et al.

(2017) both found that daily oral nutritional supplementation improved anthropometric measures in malnourished children, particularly in settings where access to adequate nutrition was limited. Additionally, Saha et al. (2015) found that a combination of both micronutrient and macronutrient supplementation can have a synergistic effect on improving both weight and height, supporting the findings of Khadilkar et al. (2021).

-Moringa Supplementation

Basri et al. (2021) demonstrated the benefits of moringa extract in pregnant women, reducing stunting in toddlers aged 36–42 months. This finding is consistent with studies such as Gupta et al. (2020), which indicated that moringa supplementation can enhance growth and nutritional outcomes in undernourished populations. However, Chandra et al. (2019) reported mixed results, where moringa supplementation did not significantly reduce stunting, suggesting that the effectiveness of moringa may depend on factors such as the timing of supplementation or the baseline nutritional status of the population.

-Micronutrient Supplementation (Vitamin A)

The study by Chen et al. (2014) on vitamin A supplementation and its combination with iron supplementation showed that while vitamin A alone did not enhance iron levels, its combination with iron had a synergistic effect. This finding is consistent with Maluccio et al. (2010), who reported that vitamin A supplementation, when combined with iron, improved iron stores in children with anaemia. However, Vaswani et al. (2017) found no significant effect of vitamin A on iron status when administered alone, which aligns with Chen et al.'s finding that vitamin A supplementation in isolation may not have a significant impact on iron mobilization.

-Educational Interventions

Educational interventions, particularly those focusing on maternal nutrition and practices, have been shown to improve nutritional outcomes for children. Ansuya (2023) found that educating mothers about protein-rich recipes led to improved child weight. This agrees with findings from Ferguson et al. (2015), who showed that maternal education on nutrition and infant feeding practices can significantly reduce childhood malnutrition. Alderman et al. (2017) also demonstrated that integrating maternal education with nutrition interventions improves child growth outcomes, particularly in resource-poor settings. This highlights the importance of empowering caregivers with knowledge as a critical factor in combating childhood malnutrition.

-Water and Sanitation Interventions

The effectiveness of WASH interventions, as demonstrated by Doocy et al. (2018), is consistent with the broader body of literature that links improved water and sanitation with better nutritional outcomes. For example, Bhutta et al. (2008) found that interventions addressing diarrhoea and other sanitation-related issues have a significant impact on child nutrition by reducing the frequency and duration of infections that contribute to malnutrition. Similarly, Lantagne et al. (2013) emphasized that access to safe drinking water and sanitation can reduce morbidity from diarrhoea, thus improving overall nutritional status and reducing the incidence of growth faltering in children.

5. LIMITATIONS

This review is limited by the small number of included studies (n=14), which affects generalizability. Significant heterogeneity in intervention types, durations, outcomes, and populations limited meta-analysis and direct comparisons. Incomplete reporting in some studies and the exclusion of non-English articles may have introduced bias.

Implications of the results for practice, policy, and future research

Practice: The findings reinforce the potential of multi-component nutrition interventions including fortified foods, oral nutritional supplements, and maternal education to improve nutritional status among preschool children. Healthcare providers and community health workers should consider combining direct nutritional support with caregiver education to maximize impact.

Policy: Given the variability in effectiveness, policymakers should avoid one-size-fits-all strategies. Instead, they should prioritize context-specific program designs that incorporate local dietary patterns, cultural practices, and infrastructure, such as access to clean water and sanitation. Nutrition policies should also integrate health education and WASH (Water, Sanitation, and Hygiene) interventions to address underlying determinants of malnutrition.

Future Research: There is a need for more rigorously designed, large-scale RCTs focused exclusively on the 3–6 years age group, particularly in low-resource settings. Future studies should explore the long-term sustainability and cost-effectiveness of integrated interventions. Furthermore, standardized outcome measures and consistent reporting practices would enhance comparability and enable stronger meta-analytical conclusions.

6. CONCLUSION

This systematic review highlights the effectiveness of various interventions including nutritional supplementation, food

fortification, education-based strategies, and WASH programs in managing malnutrition among preschool children aged 3–6 years. While some interventions demonstrated positive effects on anthropometric and biochemical outcomes, the overall evidence suggests context-dependent variability. The results support the adoption of integrated, locally tailored strategies to address malnutrition in early childhood. Continued investment in high-quality research and cross-sectoral collaboration is essential to develop and scale interventions that are both effective and sustainable.

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