

Review Article

Effectiveness of micronutrient powder intervention in reducing anemia among children under six years of age: a rapid review

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ABSTRACT

Anemia is a major public health problem among the children under six years of age. Iron deficiency is the primary cause, while deficiencies in vitamin A, folic acid, and zinc also contribute. Childhood anemia impairs the cognitive and physical development and increases the susceptibility to infections. Micronutrient powders (MNP) are widely used as home fortifiers to reduce anemia prevalence. This rapid review consolidated the evidence from observational and interventional studies on MNP use and anemia prevalence in children under six. PubMed and Cochrane were searched for the English full-text studies conducted in Asia. Eligible designs included the randomized controlled trials, cohort, case-control, and cross-sectional studies. Data extraction followed PICO based criteria, with over twelve studies meeting inclusion. MNP use consistently improved the hemoglobin levels and reduced anemia prevalence, particularly with iron inclusive formulations and high adherence. Improvements were also noted in the micronutrient status. Although effect sizes varied, supplementation generally raised hemoglobin concentrations. Program delivery structure and adherence were critical determinants of the success. MNPs significantly improve the hemoglobin concentrations and also reduce the anemia prevalence, especially among children under two years or those with moderate baseline anemia. Adherence ($\geq 75\%$) was a vital factor, with compliant studies showing substantially better outcomes. Active involvement of the community health workers in distributing MNPs and educating caregivers enhanced the program success. Targeting interventions to the vulnerable populations such as anemic or at-risk children (6–24 months) may achieve greater impact than universal administration.

Keywords: Anemia, Nutrition, Micronutrient powder, Hemoglobin, Children

INTRODUCTION

Anemia stands tall as a major public health problem among children under 6 years of age, with nutritional cause being the most common, particularly in low and middle-income countries. The latest WHO Global Anemia Estimates (2025 edition) report that 39.8% of children aged 6-59 months (under 5 years) worldwide were affected by anemia as of 2019.¹ In 2023, an analysis involving six South and Southeast Asian countries (India, Bangladesh, Cambodia, Myanmar, Maldives and Nepal) revealed childhood Anemia prevalence of 57.3% (95%,

CI:- 56.9-57.7) (Sunuwar, D.R., Singh, D.R., Pradhan, P.M.S. et al).² In India, according to National family health survey 5(2019-21), the anemia prevalence among children (6-59 months) is the prevalence of anemia in children aged 6-59 months is 67.1%. (Anemia Mukh Bharat 2022).³ Childhood anemia not only leads to impaired physical growth and cognitive development, but also increases susceptibility to infections, resulting in both short as well as long term health outcomes (Cardoso et al).⁴ The primary reason for anemia in childhood is iron deficiency, however deficiencies in other micronutrients such as vitamin A, folic acid and zinc also result in anemia.

Micronutrient powder (MNP) is widely promoted globally as home fortification for children to reduce the prevalence of anemia. Composition of MNP varies region to region, however the typical components are iron, vitamin A, zinc, folic acid and vitamin C. There are no current available published guidelines regarding the appropriate dose and frequency of MNP (UNICEF, 2021).⁵

Even though MNPs are widely promoted as a key strategy to overcome the burden of anemia prevalence, their effectiveness remains inconsistent. Some research studies have also shown undesirable or minimal results. Since, the available published studies lack the conclusiveness to prove the effectiveness of MNPs on reducing prevalence of anemia. Despite these inconsistencies, MNPs continue to be implemented across numerous nutrition programs worldwide. Creating an urgent need to integrate existing evidence. This review aims to evaluate the existing evidence on MNP effectiveness for reducing anemia in children and to identify key factors contributing to variable outcomes in different settings.

METHODS

A rapid literature review is an alternative to systematic literature review that can speed up analysis of existing published data. It is a type of evidence that streamlines the systematic review but completed within a shorter timeframe. Given time and financial resource constraints we have chosen Rapid Review to find evidence on Micronutrient Powder (MNP) intervention and their association with Anemia prevalence in children under six. This rapid review was conducted according to PRISMA methodology.⁶

Eligibility criteria

The Research question was defined in PICO format for formation of structured research question to give us focused inclusion/exclusion criteria and helps us to get evidence for our research question: Children aged between 0-6 years with or without anemia. Micronutrient Powder (MNP) interventions, alone or with other programs. Placebo or no supplementation, Standard care or non-fortified foods and alternative nutrition programs. Prevalence of anemia. As this review, intends to find evidence on association of micronutrient powder interventions with prevalence of anemia in under 6 years of children PICO is the most suitable framework for this review.

Inclusion criteria

We included original research studies conducted only in Asia like cross-sectional, case-control and cohort studies (both prospective and retrospective). We also added randomized control trials (RCT). To be eligible, studies had to report anemia prevalence as their primary or secondary outcome. All research had to focus on children

under 6 years old (usually 6-59 months), with or without caregivers as part of the study. Only English full text articles were considered.

Exclusion criteria

We left out case reports, case series and non-research articles like reviews, editorials, commentaries, and conference abstracts. Protocol papers were also excluded. Studies on animals or lab-based (in vitro) research was not part of this review and we also not included articles published in languages other than English.

Search strategy

Database searched

We searched two databases- PubMed and Cochrane-to explore existing nutritional interventions for children under 6 years old. This helped us to arrive at our research question. Later, we focused specifically on micronutrient powder (MNP) as an intervention and its association with anemia prevalence in children. Then, highly targeted search terms are used to ensure that only retrieve articles directly related to the research question.

These are the search terms used for Cochrane and PubMed:

Search strategy for COCHRANE searched on date:22-06-2025

(micronutrient* OR MNP OR "nutrition powder" OR "multiple micronutrient powder" OR "micronutrient powders" OR "home fortification" OR "point-of-use fortification" OR sprinkles OR "micronutrient supplement*" OR "micronutrient fortification") AND (anemia OR anaemia OR hemoglobin OR haemoglobin OR "iron deficiency" OR "iron status" OR ferritin OR hematologic OR haematologic OR blood) AND (child* OR infant* OR toddler* OR baby OR babies OR preschool* OR pediatric OR paediatric OR "under-five" OR "under five" OR "under 6" OR "under six").

Search strategy for PUBMED searched on date:21-06-2025

("micronutrient powder"[ti] OR "micronutrient powders"[ti] OR "multiple micronutrient powder"[ti] OR "multiple micronutrient powders"[ti] OR "home fortification"[ti]) AND ("Anemia"[MeSH Terms] OR "Anemia, Iron-Deficiency"[MeSH Terms] OR anemia[tiab] OR "iron deficiency"[tiab] OR "low hemoglobin"[tiab] OR hemoglobin[tiab] OR hematocrit[tiab] OR ferritin[tiab] OR "iron status"[tiab] OR "nutritional anemia"[tiab]) AND ("Infant"[MeSH Terms] OR "Child"[MeSH Terms] OR "Child, Preschool"[MeSH Terms] OR infant*[tiab] OR neonate*[tiab] OR newborn*[tiab] OR baby[tiab] OR babies[tiab] OR toddler*[tiab] OR child*[tiab] OR

children[tiab] OR preschool*[tiab] OR "under five"[tiab] OR "under 5"[tiab] OR "under six"[tiab] OR "6 years"[tiab] OR "6-year-old"[tiab]) AND ("intervention"[tiab] OR "interventions"[tiab] OR "supplement"[tiab] OR "supplements"[tiab] OR "supplementation"[tiab] OR "fortify"[tiab] OR "fortified"[tiab] OR "fortification"[tiab] OR "treatment"[tiab] OR "prevention"[tiab] OR "program"[tiab] OR "distribution"[tiab] OR "public health"[tiab] OR "implementation"[tiab] OR "use"[tiab] OR improve*[tiab])

This expression was applied in June 2025, and it was designed after group discussion, and we have not used any time restriction filter as we want to explore all available published article on our focused topic.

Selection of evidence

Once the records from the search were obtained, they were extracted and uploaded to Review Manager software Rayyan (SaaS or web application) where the eligibility assessment process began.⁷ While screening there was no

agreement between reviewers as the blind approach had considered to remove bias. Reviewers selected articles via two phases: primary screening and secondary screening. This phase was conducted by two independent reviewers. Initially, the articles were analyzed for their agreement with the inclusion criteria by title and abstract. After this process, the reviewers proceeded to the secondary screening by full-text review, where they in depth assessed the inclusion and exclusion criteria along with population, intervention, control and outcome of each study and conclusions of each study with the aim of answering the defined review question.

Conflicts in decisions regarding the selection of articles were resolved by detailed discussion between members of review team. The reasons for excluding the articles were categorized according to their incompatibility with the defined inclusion criteria and summarized together with the data on the selection process, in a PRISMA flow diagram (Figure 1).⁶

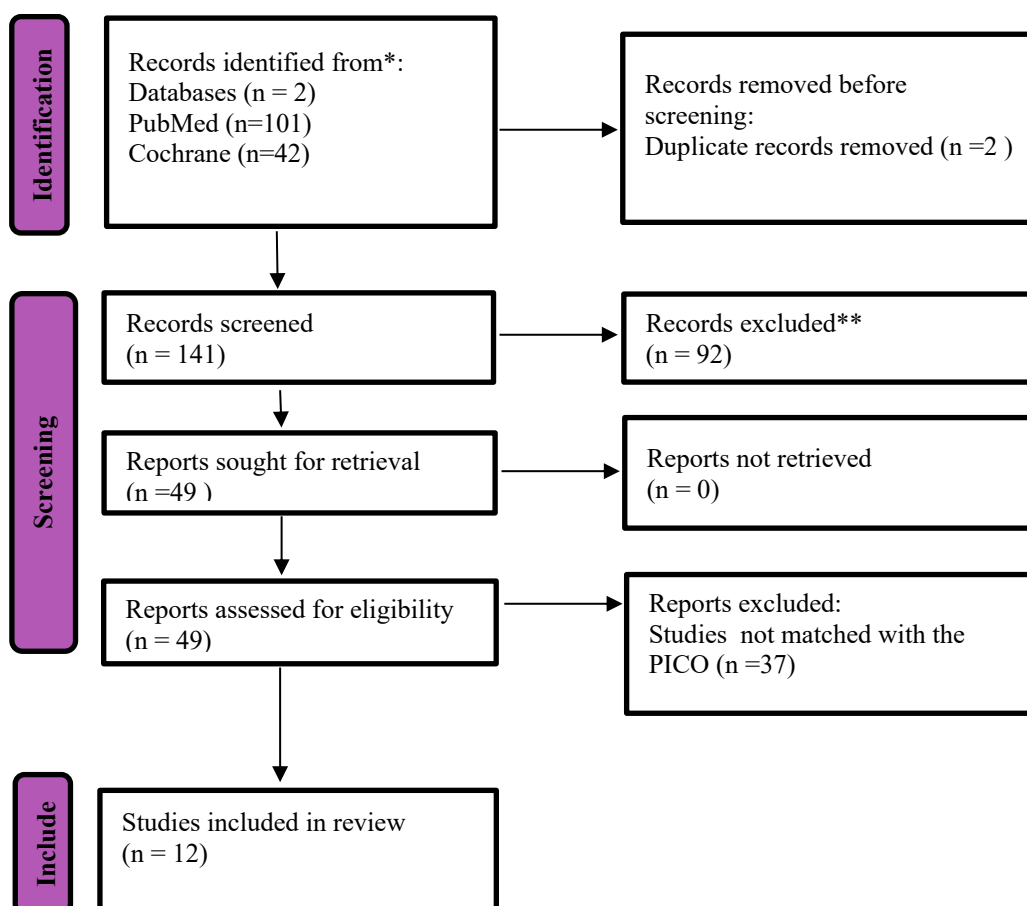


Figure 1: PRISMA flow diagram reporting the process of identification, screening, and inclusion of articles in this rapid review.⁶

Data extraction

For this rapid review, relevant data from the included studies were extracted using a pre-designed data extraction sheet that was developed and finalized in consultation with the review team. The sheet included structured fields such as study authorship, publication year, study setting (country), type of intervention, comparison groups, outcome measures, methodology and key findings.

The data extraction process was initiated after full-text screening of the eligible articles. One reviewer was primarily responsible for extracting the data into the sheet, while a second reviewer independently cross-checked the entries for accuracy and consistency. This dual-review process ensured reliability and minimized individual bias during extraction. In cases of disagreement, consensus was reached through discussion.

The inter-observer reliability was ensured throughout, following best practices for rapid reviews. All extracted data were then reorganized to match the review's specific research objectives and to allow for structured synthesis. No automation tools were used for extraction; the process was entirely manual to retain the context and nuance, especially given the variability in how outcomes were reported across studies.

Data analysis

The included studies were analyzed using a descriptive and comparative approach to assess the effects of micronutrient powders (MNPs) on anemia prevalence, hemoglobin concentration, adherence, and iron deficiency among children under six. A narrative synthesis was conducted, supported by tabulated summaries and schematic representation of included articles through the PRISMA flow diagram shown in Figure 1.⁶

RESULTS

Prevalence of anemia

Micronutrient powders (MNPs) have been widely explored for their impact on reducing anemia in children under six, with evidence showing persistently beneficial effects across various contexts. A large-scale household survey was conducted over 16,000 homes reported a drop in anemia prevalence from 46.6% to 31.2%, as MNP coverage increased substantially over time.⁸ Another independent community survey similarly observed that a 25% lower anemia prevalence among MNP recipients compared to those who have not taken MNP supplementation.⁹ There are lots of randomized controlled trials which found these results. One RCT (give author numbers or names as et al) showed anemia prevalence dropped from 72% to 52% in the MNP supplementation group while increasing from 72% to 75% in controls ($p < 0.001$), with high adherence contributing to the

effect.¹⁰ In another trial where zinc is present in MNP which was conducted in India (ref?) shows that anemia prevalence was just 10.1% in the MNP group versus 35.5% in placebo at endline, with most MNP cases being mild and placebo cases being moderate. Iron deficiency anemia (IDA) which is most common cause of mortality in children declined dramatically from 42.1% to 4.8% in the MNP group but remained 34.3% in the placebo group.¹¹ These findings show that this not only reduces the diseases burden but also improves the micronutrient status. In Nepal among children of aged 12-23 months who were enrolled in the study their mothers received at least two MNP distributions had significantly lower prevalence of anemia (APR 0.79, 95% CI: 0.65-0.96; $p = 0.02$) and IDA (APR 0.75, 95% CI: 0.58-0.95; $p = 0.02$), which are adjusted for dietary and sociodemographic factors.¹² There was another trail which shows a 7.1 percentage point decline in anemia prevalence (95% CI: -13.5, -0.7) were observed in the intervention group compared to control.¹³ A study shows the contradictory findings that overall anemia reduction with MNPs was not significant ($p = 0.14$) but there was an 11-16% decline among children who were anemic at baseline ($p = 0.06$).¹⁴ While another investigation reported a significant reduction in total iron deficiency and IDA particularly in children without inflammation, but overall anemia reduction was weakly significant.¹⁵ Together, if we put all these findings, it suggests that MNPs are effective in reducing anemia prevalence, only when coverage of MNPs is high, adherence is well maintained, and when interventions are specially for the most vulnerable subgroups such as younger or anemic children.

Hemoglobin (Hb) concentration

Across the included studies, micronutrient powder (MNP) supplementation consistently led to improvements in hemoglobin levels, although the magnitude of increase varied. For example, in a study by Black et al (2021), the hemoglobin concentration increased from 10.9 g/dL to 12.1 g/dL in the MNP group, which was significantly higher than the placebo group in which it changed from 10.9 g/dL to 11.2 g/dL. ($p < 0.0001$).¹¹ In a study by Lundeen et al (2010), the intervention group showed a 7 g/L increase in Hb levels, while the control group experienced a 2 g/L decline.¹⁰ The effect was more prominent in studies that used iron-containing MNPs. For instance, in a study by Lemaire et al (2011), there was a rise of 19.3 g/L in the MNP group compared to placebo after just two months of intervention ($p < 0.0001$).¹⁶ However, the impact was influenced by the baseline severity of anemia. In a study by Lundeen et al (2010), children with moderate anemia (Hb 70-99.9 g/L) had greater benefits compared to those with mild or no anemia at baseline.¹⁰

Adherence and compliance

Most studies with structured program delivery reported high adherence rates, often above 75%. For example, in a

study of Barffour et al (2019) they achieved 89% adherence for MNP through weekly home visits and Lemaire et al (2011) reported 100% adherence based on sachet counts.^{14,16} Similarly, study of Sarma et al (2024) observed significant increased effective coverage when community health workers were involved in distribution.⁸

However, several barriers to adherence were noted. Acceptability was also an issue in some regions. For instance, in de Pee et al study (2007), 26% of non-users mentioned that children did not like the taste of the product.⁹

Intervention providers

The delivery mechanism played a role in both coverage and adherence. Government-led programs, such as in Serdula et al study (2013) (Kyrgyz Republic Ministry of Health), reached a larger population but showed variation in compliance.¹⁵ In contrast, NGO and research-led programs like those in Luo et al study (2017) (Heinz-supplied MNPs), Thompson et al (2025) (DSM India), reported better adherence due to close monitoring, but their reach and scalability were limited.^{17,18}

Impact of hemoglobin concentration and adherence to intervention on anemia prevalence

As per our findings, improvements in hemoglobin levels generally corresponded with reductions in anemia prevalence. For example, in Black et al study (2021), the odds of anemia were 75% lower among children who received iron-folate MNPs.¹¹ Similarly, study by Lundeen et al (2010) observed a 38% cure rate when compliance exceeded 75%, highlights that adherence and sufficient program reach are key factors in determining the effectiveness of MNP interventions.¹⁰

Iron deficiency prevalence and its impact on anemia

In the randomized trial from Black et al (2021), iron deficiency in the MNP intervention group decreased markedly from 73.0% to 32.4%, while in the placebo group it remained persistently high though there was a drop (77.8% to 76.6%). This intervention also led to a significant hemoglobin improvement in the MNP group (10.9 g/dL to 12.1 g/dL), while the placebo group saw only a slight increase (10.9 g/dL to 11.2 g/dL), thereby confirming MNP as a key factor in reducing anemia.¹¹

Similarly, in Serdula et al (2013), iron deficiency at baseline was 77.3% in the total population and reduced to 63.7% after the intervention. Correspondingly, the prevalence of iron deficiency anemia (IDA) declined from 45.5% to 33.4%. These reductions were aligned with the observed decrease in overall anemia prevalence, from 50.6% to 43.8%.¹⁵

The study from Barffour et al (2019) reported a reduction in iron deficiency by 44% to 55% in the MNP group.

Ferritin levels in this group reached 26.0 µg/L, which was significantly higher compared to approximately 18 µg/L in other comparison groups. This group also achieved the highest hemoglobin levels (111.6 g/L), suggesting a clear link between improved iron status and reduced anemia.¹⁴

In Young et al study (2021), the prevalence of IDA dropped dramatically from 42.1% to just 4.8% in the MNP group, while it remained high (34.3%) in the placebo group. This drastic reduction points to the effective role of MNPs in addressing iron deficiency and related anemia.¹³

DISCUSSION

This review found out that Micronutrient powders (MNPs) does significantly improve hemoglobin concentrations and reduce anemia prevalence, especially in children under six years of age, particularly when the formulation includes iron and adherence is high. The intervention of MNPs also led to marked reductions in iron deficiency and iron deficiency anemia (IDA), especially in vulnerable subgroups such as children with moderate baseline anemia or those under 2 years of age.

The concentration of hemoglobin improvements observed are primarily attributable to the replenishment of iron stores through MNPs, which contain bioavailable iron such as ferrous fumarate or iron-EDTA. Children with moderate to severe anemia benefited more than the non-anemic children due to their lower baseline iron levels and higher absorption potential via upregulated iron transport mechanisms.¹⁹

Adherence to MNPs emerged as a crucial factor because studies with ≥75% compliance showed significantly good outcomes.²⁰ Supply chains, bad taste, and low parental knowledge were the key barriers in some settings. Community-based distribution of MNPs by trained health workers especially with weekly or biweekly distribution was associated with both higher adherence and greater impact.²¹ Also, MNPs appeared particularly effective in reducing IDA, likely due to their iron content being coupled with other supportive micronutrients like vitamin A and zinc, which synergistically increase the iron metabolism and hemoglobin synthesis.²² This finding is consistent with the mechanistic studies which show that how vitamin A's role in mobilizing iron from stores and enhancing erythropoiesis.²³ These results from this review are consistent with several systematic reviews and meta-analyses which were shows the same results as a study by Suchdev et al (2020) found that MNPs increases hemoglobin concentration and reduced anemia risk by 18% among children aged 6-23 months.²⁴ Similarly, another study by Suchdev et al (2020) confirmed that MNPs drastically reduced IDA across diverse geographies.²⁴

However, there are contradictory results that have also been reported. A Ugandan trial by Wirth et al (2017)

observed that no significant reduction in anemia was there which may be explained by various factors such as soda ash use in cooking and high prevalence of infection/inflammation that impair iron absorption.²⁵ Moreover, in the populations with low iron-deficiency burden, anemia may be characterized more by genetic hemoglobinopathies or infection which makes MNPs less effective.²⁶ These findings support the integration of MNPs into child nutrition programs, particularly in countries where there is high prevalence of anemia and iron deficiency rates.

Community health workers should actively engage in distribution of MNPs, and education is key for program success. Importantly, targeting the intervention to vulnerable population like anemic or high-risk children (e.g., 6-24 months) may yield better outcomes than universal application.²⁷ Also, the programs should consider enhancing iron bioavailability through dietary education by health activists (e.g., avoiding inhibitors like phytates and polyphenols) and addressing coexisting factors like inflammation, helminthes.

Strengths of this review include the large geographical diversity of included studies, consistent outcomes which measure Hb, anemia, IDA, and pay attention to program implementation aspects like adherence and delivery mechanisms.

Limitations

However, there are some uncertainties in our review which include heterogeneity in formulations, doses, and durations across studies. Most of the trials lacked information about inflammation markers (like CRP, AGP), which are essential for interpreting ferritin accurately. Many studies did not even report long-term sustainability or cognitive outcomes after MNPs supplementation. Publication bias may also exist because positive results are more likely to be published, and our review did not stratify outcomes based on infection status or concurrent nutritional interventions.

CONCLUSION

MNPs are therefore an effective tool to deal with anemia and iron deficiency in children under six, especially when compliance or adherence is high and delivery mechanisms are very well-structured. While this will not be universally effective in all settings but MNPs does have the potential to significantly reduce disease burden when context-specific barriers are addressed. MNPs should be viewed as part of an extensive child nutrition strategy rather than a standalone solution alone.

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