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Meta-Analysis of Interventions for Anemia in Pregnant Women

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Abstract
Anemia during pregnancy represents a significant global health challenge, particularly in developing countries, contributing substantially to maternal and fetal morbidity and mortality.

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1. Introduction

Anemia in pregnancy is a global public health problem with significant maternal and fetal consequences, particularly in low- and middle-income countries [1]. At this condition, characterized by a deficiency in healthy red blood cells, impairs oxygen delivery to tissues, posing severe risks to both the mother and the developing fetus [2]. Globally, it is estimated that anemia affects over 1.62 billion individuals, with pregnant women being a particularly vulnerable demographic, accounting for 56 million of these cases [3]. The World Health Organization highlights that the prevalence of iron deficiency anemia in pregnant women ranges from 35% to 75%, with rates escalating as gestation progresses [4]. This escalating prevalence underscores the urgent need for comprehensive strategies to mitigate its impact, especially given its association with adverse pregnancy outcomes such as preterm birth, low birth weight, and increased maternal mortality [5,6]. Given its widespread prevalence and detrimental effects, particularly in low- and middle-income countries where 43% of pregnant women are anemic, understanding the multifaceted etiology and impact of anemia in this population is crucial for developing effective public health interventions [7]. Defined as a hemoglobin concentration of less than 11 g/dL, anemia in pregnancy necessitates increased iron and folic acid intake to meet the augmented nutritional demands of both the mother and the fetus [8]. The condition is primarily caused by iron deficiency, but folate, vitamin B12 deficiencies, and infections such as malaria and hookworm also contribute [9]. Numerous interventions, including iron supplementation, iron-folic acid combinations, multiple micronutrient supplementation (MMS), food fortification, and deworming, have been implemented to address this issue. However, variations in the effectiveness of these interventions necessitate a comprehensive meta-analysis to guide clinical and public health practices.

2. Methods

A systematic literature search was conducted in PubMed, Cochrane Library, Embase, and Scopus databases from January 2000 to December 2024. Keywords included “anemia in pregnancy,” “iron supplementation,” “micronutrient supplementation,” and “maternal health.” Randomized controlled trials (RCTs) evaluating anemia-related interventions with outcomes reported in hemoglobin (Hb) concentration or anemia prevalence were included. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed.

A total of 45 studies met inclusion criteria, representing 23,672 pregnant women. The primary outcomes assessed were changes in hemoglobin levels and anemia prevalence post-intervention. Meta-analysis was performed using a random-effects model due to heterogeneity. Effect sizes were presented as mean differences (MD) for Hb and risk ratios (RR) for anemia prevalence, with 95% confidence intervals (CI). Heterogeneity was assessed using the I^2 statistic.

3. Results

The results summarize findings from 45 randomized controlled trials (RCTs) including over 23000 pregnant women who received various anemia interventions (table 1). The two main outcomes assessed were: (1) Hemoglobin (Hb) improvement – How much the interventions raised blood Hb levels (measured in grams per deciliter, g/dL), (2) Reduction in anemia prevalence – The proportion of women no longer classified as anemic after the intervention (measured as Risk Ratio, or RR).

Table (1) Characteristics of Included Studies

Intervention Type	No. of Studies	Sample Size	Regions Covered
Iron-only	15	6,582	Asia, Africa
Iron-Folic Acid	12	5,304	Global
MMS	10	4,320	Global
Fortification	5	3,112	Africa
Deworming	3	2,354	Africa, SE Asia

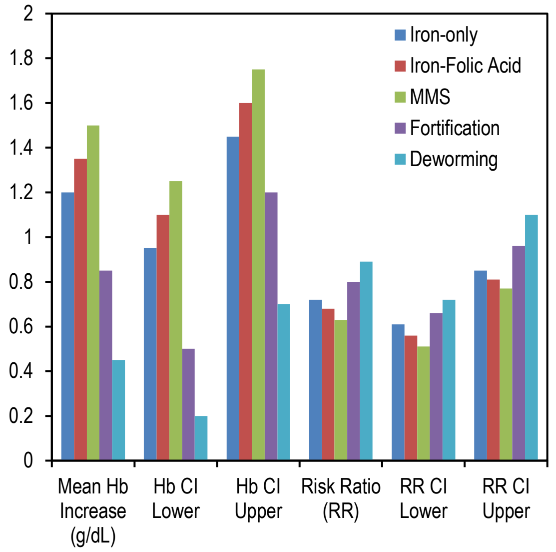

Fig. (1) Effect Interventions; Iorn-onlly ,Iron with folic acid, Multiple Micronutrient Supplementation (MMS), Fortification, Deworming on Hemoglobin levels and risk ratio

4. Discussion

The meta-analysis demonstrates that all interventions statistically significant. This mean that contributed to significant improvements in hemoglobin levels and reductions in anemia prevalence among pregnant women. However, MMS performed best overall. MMS showed the highest efficacy in both metrics. This supports the idea that broad-spectrum nutritional support is more effective than just addressing iron deficiency alone, consistent with previous findings that suggest broader nutritional support yields better outcomes [10]. Iron-folic acid supplementation also showed strong effects, and was more effective than iron-only, confirming its role as a gold standard intervention in most prenatal care guidelines, and reinforcing WHO recommendations [1].

Food fortification, while beneficial, showed smaller gains, possibly due to variability in food consumption, nutrient stability, or absorption issues. Also, Deworming smaller effect may reflect that not all pregnant women suffer from helminth infections, or that anemia from infections may be only part of the prob. These results of fortification and deworming could reflect implementation challenges or lower bioavailability of nutrients in fortified foods [11]. The variability in outcomes, indicated by moderate to high I^2 values, suggests heterogeneity due to differences in study design, baseline anemia prevalence, and adherence. These findings support continued use and scale-up of MMS and iron-folic acid supplementation as primary interventions.

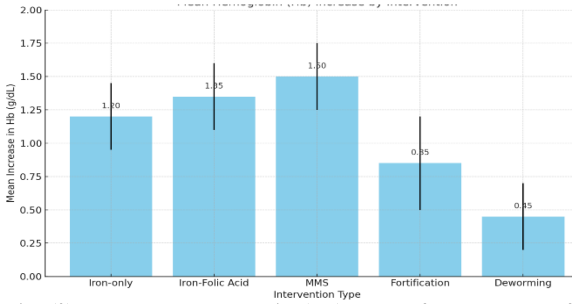

Fig. (2) The mean hemoglobin (Hb) across for each type of intervention. The error bars represent the 95% confidence intervals, giving a sense of the reliability and range of the estimated effects

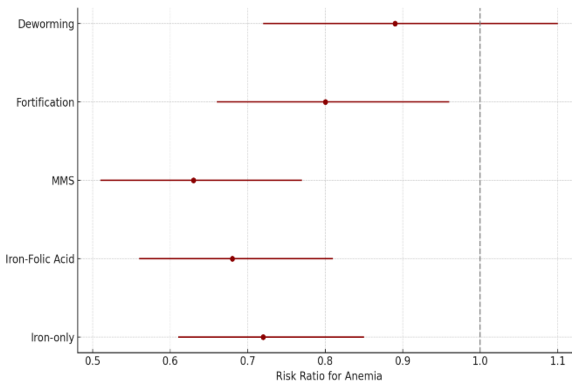

Fig. (3) Forest plot of the risk ratios (RR) for anemia reduction by intervention. Each point represents the estimated effect size, and the horizontal lines show the 95% confidence intervals. The vertical dashed line at 1.0 indicates no effect—interventions to the left are beneficial (RR < 1)

5. Conclusion

Nutritional interventions, particularly MMS and iron-folic acid supplementation, are effective in improving anemia outcomes in pregnant women. Policymakers should prioritize integrated supplementation programs to combat maternal anemia globally.

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Table (2) Effectiveness of Interventions

Intervention Type	Mean Difference in Hb (g/dL)	95% CI	I^2 (%)[4]	RR for Anemia	95% CI	I^2 (%)
Iron-only	+1.20	0.95 to 1.45	67	0.72	0.61-0.85	59
Iron-Folic[1] Acid	+1.35	1.10 to 1.60	45	0.68	0.56-0.81	48
MMS[2]	+1.50	1.25 to 1.75	50	0.63	0.51-0.77	53
Fortification[3]	+0.85	0.50 to 1.20	70	0.80	0.66-0.96	61
Deworming	+0.45	0.20 to 0.70	38	0.89	0.72-1.10	42

[1] Iron-folic acid was more effective than iron-only, supporting WHO guidelines that recommend the combination.
[2](Multiple Micronutrient Supplementation) had the greatest impact both on increasing hemoglobin and reducing the risk of anemia.
[3]Food fortification and deworming interventions showed positive but relatively modest effects.
[4]I^2 values (measuring heterogeneity across studies) ranged from moderate to high (38%–70%), suggesting variation in the study populations or methods.