



Impact of Iron-Fortified Rice on Anaemia Among Adolescent Girls in Tribal Areas: A Comprehensive Literature Review

Sandhya Rajbhar¹, Parmar Riddhi², Parmar Nidhi³, Khede Purnima⁴

1. Asst. Professor, Parul Institute of Nursing, Parul University, Vadodara, Gujarat

2-4 Post Basic B.Sc. Nursing Students, Parul Institute of Nursing, Parul University, Vadodara

Corresponding Author-Mrs. Sandhya Rajbhar, Email: s.kumari141214@gmail.com

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Abstract

Background: Anemia, particularly iron-deficiency anemia (IDA), continues to pose a major public health concern in India, with adolescent girls being among the most vulnerable. This condition leads to impaired physical growth, reduced cognitive performance, and increased risk during pregnancy. Tribal communities, owing to their socioeconomic constraints and dietary insufficiencies, exhibit disproportionately high anemia prevalence. Among emerging interventions, fortification of staple foods such as rice with iron presents a promising, sustainable strategy to address this burden.

Objective:

To comprehensively review and synthesize existing literature on the impact of iron-fortified rice in reducing anemia prevalence among adolescent girls, with a focus on tribal and underserved populations in India. **Methods:** A systematic literature review was conducted using databases including PubMed, Google Scholar, and national health repositories. The review included peer-reviewed studies, government policy documents, and programmatic evaluations from 2015 to 2024. Selection criteria included studies evaluating iron-fortified rice interventions targeting adolescent girls aged 10–19 years in tribal or rural settings. **Results:** Substantial evidence from randomized controlled trials (RCTs), field evaluations, and public health programs indicates that iron-fortified rice leads to significant improvements in hemoglobin levels and reductions in anemia prevalence among adolescent girls. Notable initiatives, including the RIDDHI project in Maharashtra, have demonstrated statistically significant gains in hemoglobin levels and declines in moderate-to-severe anemia following six months of intervention. **Conclusion:** Iron-fortified rice serves as an efficacious and scalable public health intervention, particularly in high-risk tribal areas. Its integration into national nutrition schemes such as the Mid-Day Meal Program, Integrated Child Development Services (ICDS), and Public Distribution System (PDS) can accelerate India's progress toward achieving its Anaemia Mukt Bharat (Anaemia-Free India) objectives.

Keywords: Anemia, Iron Deficiency, Food Fortification, Adolescent Health, Tribal Communities, Iron-Fortified Rice, Public Health Nutrition

1. Introduction

Anaemia, especially iron-deficiency anaemia (IDA), remains a major public health issue globally, and India bears the highest burden in the world. Among adolescent girls, the prevalence is particularly concerning due to rapid growth, onset of menstruation, and dietary deficiencies. According to the National Family Health Survey-5 (NFHS-5), more than 50% of Indian adolescent girls are anaemic, with higher rates among tribal communities, where access to healthcare, balanced nutrition, and supplementation is severely limited.

Tribal communities often subsist on monotonous diets rich in carbohydrates but poor in micronutrients, contributing to chronic nutritional deficits. In such settings, conventional supplementation approaches face barriers such as low compliance, lack of awareness, and limited outreach. Therefore, staple food fortification, particularly iron fortification of rice—a dietary mainstay—has emerged as a sustainable and culturally acceptable intervention.

This review focuses on synthesizing the existing literature on the role of iron-fortified rice in mitigating anaemia among adolescent girls, especially in marginalized tribal populations.

2. Methodology

A comprehensive literature search was conducted using the following electronic databases: PubMed, Scopus, ScienceDirect, Google Scholar, and JSTOR. Additionally, relevant grey literature, including program evaluations and government policy documents (e.g., FSSAI guidelines, Poshan Abhiyan reports), were reviewed.

Inclusion criteria:

- Studies published between 2015 and 2024
- Peer-reviewed articles, RCTs, program evaluations
- Focus on adolescent girls aged 10–19 years
- Interventions involving iron-fortified rice
- Conducted in tribal, rural, or underserved populations
- Articles written in English

Exclusion criteria:

- Studies on general populations or adults only
- Interventions involving iron supplements or other food vehicles (e.g., flour, milk)

Search terms included: “iron-fortified rice,” “adolescent anaemia,” “tribal health,” “micronutrient fortification India,” “anaemia intervention rural,” “public health nutrition adolescent.”

3. Review of Literature

3.1 Burden of Anaemia Among Adolescents

India's adolescent population, comprising approximately 253 million individuals, is disproportionately affected by nutritional anaemia. In tribal areas like Nandurbar (Maharashtra), anaemia prevalence among adolescent girls exceeds 70%, often resulting in impaired cognitive development, fatigue, and increased susceptibility to infections.

3.2 Rationale for Iron Fortification of Rice

Rice is consumed daily by a large majority of Indian households, including tribal populations. Fortifying rice with iron allows for passive intake of the nutrient without requiring behavior change. FSSAI recommends fortifying rice with 28–42.5 mg of elemental iron per kg, along with other micronutrients. The fortified kernels are blended with regular rice at a ratio of 1:100.

3.3 Evidence from Randomized Controlled Trials and Programs

Kalaivani et al. (2018)

A controlled trial in rural Tamil Nadu demonstrated that adolescents consuming fortified rice had a mean haemoglobin increase of 1.2 g/dL after three months. Anaemia prevalence reduced from 65% to 42%.

Thomas et al. (2021)

An RCT in Chhattisgarh showed improved iron biomarkers and reduction in fatigue scores among adolescent girls after daily consumption of fortified rice for six months.

RIDDHI Project, Maharashtra (2022–2023)

Conducted in the tribal blocks of Akkalkuwa, Akrani, and Dhadgaon in Nandurbar district, this randomized control trial involved 5786 adolescent girls. The intervention group received iron-fortified rice through the PDS, while the control group continued with regular rice.

Key findings:

- Baseline anaemia prevalence: 81.7%
- Mean haemoglobin increased by 0.87 g/dL in the intervention group (vs. 0.23 g/dL in controls)
- Significant reduction in moderate and severe anaemia
- Greater impact observed in girls with $\geq 60\%$ compliance to fortified rice consumption

These findings emphasize the feasibility and effectiveness of delivering fortified rice through existing public distribution frameworks.

4. Discussion

The reviewed literature consistently supports the effectiveness of iron-fortified rice in improving haemoglobin levels and reducing anaemia among adolescent girls. It offers a cost-effective, scalable solution, particularly in resource-constrained tribal areas where traditional supplementation programs struggle.

However, successful implementation requires:

- Ensuring regular supply and quality control of fortified rice
- Behavior change communication to improve acceptability and compliance
- Monitoring systems to track hemoglobin levels and health outcomes
- Interdepartmental coordination between food, health, and education sectors

Despite logistical challenges, fortified rice interventions—when embedded into existing systems like the Mid-Day Meal Scheme, ICDS, and PDS—can yield significant public health dividends.

5. Conclusion

Iron-fortified rice is a proven, evidence-based intervention to address iron-deficiency anemia among adolescent girls. The strategy is particularly relevant in tribal regions where dietary iron intake is low and programmatic outreach is limited. As demonstrated by projects such as RIDDHI in Maharashtra, the integration of rice fortification into public food programs can substantially reduce anemia prevalence and improve adolescent health outcomes.

Given the potential for long-term impact, fortified rice should be prioritized in state and national nutrition agendas as a key component of anemia control.

6. Recommendations

- **Policy Integration:** Mainstream rice fortification into all relevant national schemes—PDS, Mid-Day Meals, and ICDS.
- **Monitoring and Evaluation:** Establish routine assessment protocols for hemoglobin monitoring and program impact evaluation.
- **Community Engagement:** Strengthen communication strategies to enhance awareness and compliance among adolescent girls and their caregivers.
- **Capacity Building:** Train front-line workers and educators in nutrition counseling and program delivery.
- **Research Expansion:** Conduct longitudinal studies to evaluate long-term outcomes and optimize iron dosing for adolescents.



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