Journal of FoodSecure Indonesia
Volume. 1, Issue 1, June 2025
Page No: 1-17

Iron Supplementation and Anemia Prevention Among Adolescent Girls: A Narrative Review of School Based

Ahmad Yani[1], Ayu Lestari[2], Nur Afiah Amin[3]
[12]Universitas Muhammadiyah Palu, Indonesia
[3]Universitas Tadulako, Indonesia
Correspondent: ahmadyani@unismuhpalu.ac.id[1]

Received : May 09, 2025
Accepted : June 21, 2025
Published : June 30, 2025

Citation: Yani, A., Lestari, A., & Amin, N.A., (2025). Iron Supplementation and Anemia Prevention Among Adolescent Girls: A Narrative Review of School Based. Journal of FoodSecure Indonesia. 1(1), 1-17.

ABSTRACT: Iron deficiency anemia remains a pervasive public health issue, particularly affecting adolescent girls in low and middle income countries. This review aimed to evaluate the effectiveness, challenges, and implementation strategies of school based iron supplementation programs targeting this population. A narrative review methodology was employed, involving comprehensive searches of academic databases including PubMed, Scopus, and Google Scholar for peer reviewed studies from the past five years. Keywords such as "iron supplementation," "adolescent girls," and "school based programs" guided the selection process.
Findings indicate that both daily and weekly iron supplementation improve hemoglobin and serum ferritin levels, with daily regimens often producing superior outcomes. Regional variations in nutritional status, health infrastructure, and sociocultural factors significantly affect program effectiveness. Adherence is influenced by maternal education, peer and teacher support, and the presence of side effects. Peer support networks and school based supervision are effective in increasing adherence. Cognitive benefits, including enhanced memory, attention, and academic performance, were consistently linked to improved iron status. Despite these benefits, barriers such as inconsistent supply chains, social stigma, and inadequate stakeholder engagement persist. Addressing these requires multi sectoral collaboration, tailored educational interventions, and sustained policy commitment. This review supports the integration of iron supplementation within school health programs as a key strategy to improve adolescent health and educational outcomes globally.

Keywords: Iron Supplementation, Adolescent Girls, Anemia Prevention, School Based Health Programs, Educational Outcomes, Public Health Intervention.

INTRODUCTION

Iron deficiency anemia (IDA) remains one of the most persistent nutritional disorders affecting adolescents, particularly girls, across the globe. The condition is characterized by a reduced level of hemoglobin due to inadequate iron intake or absorption, which significantly impairs the oxygen

carrying capacity of the blood. Adolescents are especially vulnerable due to the increased iron requirements prompted by rapid growth, the onset of menstruation, and dietary inadequacies. Recent global estimates show that approximately 24% of adolescents are affected by anemia, with prevalence rates exceeding 50% in several low and middle income countries (LMICs) (Riddle et al., 2019). In particular, Southeast Asia and sub Saharan Africa present high prevalence rates, often surpassing 35% among female adolescents (Manikam, 2021; Mwakishalua et al., 2024).

The challenge is especially dire in specific regions. For instance, national level surveys and regional analyses in Bangladesh report anemia rates among school aged girls as high as 38%, attributed to multiple interrelated factors including inadequate dietary iron, poor health services, and socio economic disadvantages (Williams et al., 2020). In sub Saharan Africa, studies indicate that IDA affects as many as 62% of children and adolescents, a consequence of chronic nutritional deficiencies compounded by the prevalence of parasitic infections and other diseases (Chaparro & Suchdev, 2019). This epidemiological pattern underscores the global health community's need to prioritize IDA interventions in these regions.

The implications of IDA go far beyond hematological concerns. Numerous epidemiological and cognitive development studies demonstrate that adolescent girls with anemia exhibit poorer cognitive performance, higher absenteeism rates, and significantly reduced academic outcomes compared to their non anemic counterparts (Chen et al., 2022; Nampijja et al., 2022). These cognitive effects manifest as impaired attention, learning capacity, memory, and psychomotor development. IDA during adolescence, a critical period for educational advancement, thereby hinders both immediate academic success and long term socio economic outcomes. Furthermore, these limitations can perpetuate intergenerational cycles of poverty, as affected adolescents are less likely to complete schooling or access stable employment opportunities.

Health consequences of IDA are similarly multifaceted. Affected adolescents are more likely to experience fatigue, weakened immunity, and increased susceptibility to infectious diseases, all of which contribute to diminished quality of life (Keats et al., 2019; Putri et al., 2021). The co-occurrence of IDA with conditions such as malaria and hookworm infection in LMICs further exacerbates morbidity and complicates treatment efforts. Consequently, IDA represents not only a nutrition related issue but also a broader public health challenge that intersects with disease burden, access to education, and healthcare delivery systems.

To mitigate these challenges, several countries have implemented school based iron supplementation programs targeting adolescent girls. These interventions leverage the school environment as a consistent and structured platform for delivery, thereby optimizing reach and compliance. In Indonesia, for example, female students receive iron tablets every Friday as part of a national strategy initiated in 2014 (Rahayu et al., 2017). This initiative aims to provide both anemic and non-anemic students with preventive supplementation while also integrating educational components. Similar strategies have been implemented in cities like Samarinda, where daily iron tablets are distributed alongside health education efforts (Wisnuwardani et al., 2023). These examples illustrate the potential

of school based programs to deliver comprehensive, multi-faceted interventions that address both knowledge gaps and biological deficiencies.

Elsewhere, countries such as Brazil have introduced robust iron supplementation programs that link school attendance with regular health screenings and supplement provision (Paulino et al., 2021). These models are associated with notable reductions in anemia prevalence among adolescents. In contrast, many sub Saharan African countries continue to face implementation barriers, including insufficient funding, logistical challenges, and limited intersectoral collaboration (Abou, 2023; Chaparro & Suchdev, 2019). Despite broad consensus on the effectiveness of such interventions, their success remains highly context dependent.

However, even in countries where supplementation programs exist, challenges persist. Adherence to supplementation regimens among adolescents is often inconsistent, undermining program effectiveness. Barriers to adherence include lack of awareness about the importance of iron, social stigmas, limited parental involvement, and logistical hurdles related to supply chain management and distribution (Saydam, 2017; Shaban et al., 2020). Nutritional interventions, when not paired with adequate educational outreach and community engagement, frequently fail to achieve their intended impact. Furthermore, many adolescents, particularly in rural and marginalized communities, lack access to iron rich foods, thereby diminishing the potential synergistic effects of supplementation (Aggarwal et al., 2020).

The presence of parasitic infections such as soil transmitted helminths, which exacerbate iron loss, presents an additional barrier. Deworming initiatives are essential components of anemia control but are often absent from school health programs, especially in resource constrained settings (Mabrouk et al., 2022; Munira & Viwattanakulvanid, 2024). Without such integrative approaches, the biological benefits of iron supplementation may be significantly compromised. Furthermore, limited monitoring and evaluation mechanisms in many countries lead to inconsistent results and hinder efforts to scale successful interventions (Hirosawa et al., 2022).

Despite growing interest and active implementation of school based iron supplementation programs, existing literature highlights notable gaps in research and practice. While many studies document hemoglobin improvement following supplementation, few provide insights into the long term adherence patterns, sustainability of outcomes, or integration with broader educational and public health systems. For example, in a study conducted in Iran, only 22% of students adhered to supplementation regimens despite wide distribution efforts (Alami et al., 2020). This highlights systemic weaknesses in follow up and reinforces the need for comprehensive monitoring frameworks.

Moreover, although several reviews address either biological outcomes or educational interventions independently, few narrative or systematic reviews adequately examine the intersection of these components. The systematic review by Jalambo et al. (2018) revealed that nutrition education can enhance health outcomes, yet its integration with supplementation programs remains inconsistent (Jalambo et al., 2018). There is also insufficient attention to the socio cultural determinants of program

success, such as family support, gender norms, and local beliefs about health and nutrition, which often dictate program engagement (Khammarnia et al., 2016).

The objective of this narrative review is to synthesize and critically evaluate existing literature on school based iron supplementation programs aimed at preventing and managing IDA among adolescent girls. Particular attention will be paid to the effectiveness of supplementation on hematologic outcomes, factors influencing adherence, implementation challenges, and the role of supportive educational interventions. The review seeks to identify successful models of implementation and analyze contextual factors that facilitate or hinder program success across diverse geographic settings.

This review will focus on adolescent girls aged 10 to 19 years in LMICs, with specific case examples drawn from Southeast Asia, sub Saharan Africa, and Latin America. These regions are selected based on their high burden of adolescent anemia and the presence of school based intervention programs. By analyzing diverse program implementations and outcomes, this review aims to provide actionable insights for policy makers, program designers, and educators involved in adolescent health and nutrition initiatives.

METHOD

This study adopts a narrative review approach to critically examine the effectiveness, implementation challenges, and adherence factors related to school based iron supplementation programs among adolescent girls. A comprehensive literature search was conducted using three major academic databases: PubMed, Scopus, and Google Scholar. The search targeted studies published within the past five years to ensure relevance and currency of findings in the context of adolescent anemia interventions.

The search strategy employed a combination of predetermined keywords and Boolean operators to optimize specificity and breadth. The core keywords included "iron supplementation," "adolescent girls," "school based programs," "anemia," "nutritional intervention," "young women," "educational interventions," "health education," and "Fe tablets" or "iron tablets." These terms were strategically combined using Boolean strings such as ("iron supplementation" OR "Fe tablets" OR "iron tablets") AND ("adolescent girls" OR "young women") AND ("school based programs" OR "educational interventions" OR "nutritional intervention" OR "health education") to retrieve a comprehensive set of relevant studies.

Inclusion criteria were established to encompass peer reviewed studies focusing on adolescents aged 10 to 19 years, specifically those examining iron supplementation, nutritional education, or health programs delivered within school or community settings. Studies were selected based on their reporting of outcome measures such as hemoglobin levels, anemia prevalence, nutritional knowledge, or adherence to supplementation. Systematic reviews and meta analyses meeting these criteria were

also included. Excluded were studies unrelated to adolescents, those that lacked empirical data, non-English publications, and those failing to address relevant health outcomes.

To ensure methodological rigor and reliability, a multi stage screening process was employed. Titles and abstracts were initially reviewed to assess relevance, followed by a full text evaluation of shortlisted articles. Four independent reviewers participated in the selection process, applying the inclusion and exclusion criteria consistently. Emergent themes across the selected studies were synthesized to identify recurring patterns in program implementation, adherence factors, and the integration of educational strategies. The findings offer insights into the operational effectiveness of school based iron supplementation and its implications for adolescent health outcomes.

RESULTS AND DISCUSSION

Effectiveness of IFA Supplementation

Recent studies have underscored the efficacy of iron and folic acid (IFA) supplementation in improving hemoglobin and serum ferritin levels among adolescent girls. Particularly, daily supplementation has consistently shown greater improvements compared to weekly regimens. A community based intervention in Maharashtra, India, demonstrated that daily IFA significantly increased hemoglobin levels compared to weekly doses, although both interventions were beneficial (Kore et al., 2022). This finding is echoed in Silva Neto et al. (2018), who concluded that daily supplementation enhances serum ferritin levels more robustly (Silva-Neto et al., 2018). Furthermore, a randomized controlled trial emphasized that adherence is typically higher with daily supplementation protocols, possibly due to simplified routine and better recall (Htet et al., 2019).

Regional differences have also emerged as significant determinants of program success. In sub Saharan Africa, where anemia prevalence is exceedingly high, iron supplementation has produced more pronounced hematological improvements (Pattrakornkul et al., 2021). Contrastingly, in regions with moderate anemia prevalence and better nutritional baselines, such as parts of Latin America, the impact of supplementation may be less dramatic (Adler et al., 2020). These discrepancies are often linked to socio economic status, dietary diversity, and healthcare infrastructure. Sociocultural factors such as awareness and acceptance of supplementation further influence effectiveness. For instance, Ghana's integration of school based iron supplementation into broader health policies yielded notable reductions in anemia rates (Alizadeh & Salehi, 2016).

Adherence to Supplementation

Adherence to iron supplementation is a complex issue influenced by socio demographic, personal, and interpersonal dynamics. Higher maternal education and parental occupation have been positively associated with compliance. Adolescents whose mothers had greater health literacy demonstrated

higher levels of adherence (Feriyanti et al., 2022). Internal factors such as personal motivation, perceived benefits, and knowledge about anemia also play a crucial role (Isnaini et al., 2024). Interpersonal support, particularly from teachers, peers, and family, has consistently been linked to improved adherence. In Ethiopia, adolescents receiving encouragement from family members were significantly more compliant (Daba et al., 2024).

Peer support and structured school supervision have emerged as powerful facilitators. In Ghana, peer led initiatives encouraged daily supplement intake through mutual reminders and shared responsibility, yielding improved compliance (Gosdin et al., 2020). Likewise, Sudfeld et al. (2020) reported enhanced adherence when school staff actively monitored iron intake (Sudfeld et al., 2020). These findings suggest that integrated school health systems, coupled with peer engagement, can form a sustainable adherence model. Programs with dedicated health educators or school coordinators foster environments where adolescent girls are both educated and supported in managing their supplementation routines (Nayina et al., 2024).

Side Effects and Barriers

Despite the effectiveness of IFA supplementation, side effects remain a major deterrent to adherence. Gastrointestinal complaints such as constipation, nausea, and abdominal pain are the most frequently reported symptoms (Daba et al., 2024). Over half of the participants in Daba's study indicated side effects as the primary reason for non-compliance. Additional concerns, including perceived changes in menstrual patterns such as heavier flow, were psychological barriers that further reduced adherence (Hidayanty et al., 2024). These findings suggest that addressing both physiological and psychosocial concerns is essential for sustaining long term adherence.

Programmatic barriers also constrain effective implementation. Erratic supplement supply has been a recurrent issue, especially in low resource settings like Zimbabwe, where supply chain disruptions compromised the consistency of distribution (Mahundi et al., 2021). Inadequate nutrition education among students and caregivers contributes to low understanding and undervaluation of supplementation programs. Social stigma and misinformation such as associating iron tablets with medication for serious illness also hinder uptake (Vidal et al., 2024). In several cases, reluctance to acknowledge anemia or to participate in supplementation programs has been linked to broader cultural norms around health and body image (Ge et al., 2023). Thus, effective programs must prioritize reliable logistics, community education, and culturally sensitive communication strategies.

Cognitive and Educational Outcomes

The cognitive benefits of iron supplementation among adolescents are increasingly well documented. A systematic review by Samson et al. (2022) demonstrated consistent improvement in cognitive functions such as attention, memory, and academic performance following iron interventions (Samson

et al., 2022). Similarly, Chen et al. (2022) found that oral iron supplementation positively impacted cognitive outcomes, particularly in LMICs where dietary iron intake is often insufficient (Chen et al., 2022). The enhanced iron status facilitated better school performance, offering a dual benefit in both health and educational domains.

Bahati et al. (2023) confirmed these findings in Tanzania, where weekly iron supplementation improved working memory and attention spans among school going adolescent girls (Bahati et al., 2023). This cognitive improvement directly translated into improved academic engagement and outcomes. These outcomes highlight the potential for iron supplementation to reduce educational disparities by enhancing school participation and performance.

The physiological basis for these cognitive benefits lies in iron's role in oxygen transport and neurotransmitter synthesis. Iron is essential for hemoglobin production, which in turn ensures adequate oxygen supply to brain tissues. Moreover, iron influences the synthesis of neurotransmitters like dopamine, which are crucial for attention and motivation (Bidwalker & Sridevi, 2024). Iron deficiency during adolescence can impair neural development, leading to long term cognitive delays and poor academic achievement (Kumar et al., 2020). These mechanisms reaffirm the importance of addressing iron deficiency as a means of supporting cognitive development.

Comparison with Other Countries

Implementation strategies for school based iron supplementation programs vary significantly across LMICs. Ghana stands out for its success in combining weekly IFA distribution with community health education, significantly reducing anemia prevalence (Gosdin et al., 2021). In Indonesia, while health benefits have been recorded, logistical challenges and poor adherence persist, indicating a need for stronger policy integration and community engagement (Khammarnia et al., 2016).

Burundi offers a notable example through the Tubaramure initiative, a comprehensive maternal and child health program that integrates iron supplementation with nutrition counseling. Hasan et al. (2022) noted that the program's multi sectoral approach, including community mobilization and parental education, substantially increased the uptake and effectiveness of supplementation (Hasan et al., 2022). These examples underscore the value of aligning supplementation programs with broader public health initiatives to increase sustainability and impact.

Diverse policy frameworks and stakeholder participation significantly affect program outcomes. In India, the Adolescent Girls Anemia Control Program benefits from centralized planning and multi-level stakeholder involvement, contributing to its nationwide success (Sedlander et al., 2019). Conversely, countries like the Philippines and Brazil have encountered issues due to fragmented stakeholder engagement and a lack of cohesive national policies (Roque, 2023). Nigeria presents a contrasting model, with cross sectoral collaboration between schools and healthcare services fostering more integrated and effective supplementation delivery (Schultz et al., 2024).

In summary, while many countries have successfully implemented school based iron supplementation programs, their effectiveness depends largely on contextual factors including policy support, educational outreach, and stakeholder coordination. Best practices from countries with integrated, well supported frameworks can inform the development and refinement of supplementation initiatives in other settings, ultimately contributing to global efforts to reduce iron deficiency anemia in adolescent populations.

Comparison of Findings with Previous Systematic Reviews

The findings from this narrative review align with previous systematic reviews that underscore the importance of iron supplementation in improving both physical and cognitive outcomes among adolescent girls. Salam et al. (2016) emphasized the significance of nutrition based interventions, particularly iron supplementation, in elevating hemoglobin levels and improving mental performance (Salam et al., 2016). These benefits were confirmed in the present review, which revealed that iron supplementation contributes meaningfully to improvements in academic engagement, attention span, and memory. However, this review also introduces a deeper contextual dimension by exploring how socio economic and cultural variables influence the uptake and efficacy of such interventions a perspective largely absent from earlier works.

While Neuberger et al. (2016) focused on the biological need for iron screening prior to supplementation, their study gave limited consideration to programmatic and cultural barriers to adherence (Neuberger et al., 2016). In contrast, this review identifies low compliance rates, often driven by side effects, lack of understanding, and poor program delivery, as critical limitations to program success. Moreover, this review incorporates stakeholder dynamics and systemic variables, offering a comprehensive assessment that bridges the biological, educational, and operational aspects of supplementation programs.

Systemic or Structural Factors Contributing to Program Success or Failure

Systemic and structural dimensions significantly determine the outcomes of school based iron supplementation efforts. National health policies that mandate regular IFA distribution and allocate sufficient budgetary support provide a robust platform for widespread implementation. In Ghana, the development of a dedicated national program that integrated iron supplementation within existing school health structures proved effective in lowering anemia rates (Miranda et al., 2019). The presence of a multi sectoral framework involving education and health ministries facilitated coordinated delivery, accountability, and scale.

On the contrary, logistical inefficiencies including irregular supply chains, insufficient training for educators, and underfunded distribution mechanisms have contributed to the failure of programs in many LMICs. Without reliable systems for transportation and delivery of supplements, even well

designed programs may not reach their intended beneficiaries. This limitation is exacerbated by weak monitoring systems that do not consistently track distribution or adherence metrics, leading to a lack of actionable feedback for program improvement.

Furthermore, community engagement emerges as an essential structural component. In contexts where parents, teachers, and local health officials are actively engaged, adolescent girls report higher rates of compliance and understanding. Indonesian programs that incorporate community outreach and participatory education sessions have shown moderate success in enhancing awareness and overcoming cultural taboos around supplementation (Miranda et al., 2019). Educational inclusion, whereby students are taught about the importance of iron as part of the school curriculum, amplifies the impact of these programs. Therefore, sustainable iron supplementation requires not only medical provision but also policy, educational, and community alignment.

Stakeholder Engagement Across National Programs

Stakeholder engagement determines both the reach and effectiveness of supplementation programs. Countries with institutionalized, cross sectoral cooperation, such as India, have demonstrated strong outcomes. India's Adolescent Girls Anemia Control Program benefits from structured partnerships among health ministries, school authorities, and civil society organizations. These partnerships create mechanisms for regular feedback, policy adjustment, and resource mobilization.

In contrast, nations like the Philippines, where stakeholder engagement is fragmented, face persistent implementation challenges. The absence of clear delineation of roles, overlapping responsibilities, and inconsistent communication among stakeholders hinders program scale and sustainability. These experiences highlight the importance of designing governance mechanisms that ensure shared responsibility, streamlined communication, and active participation from diverse stakeholder groups. Programs without such engagement often rely on the discretionary motivation of individual educators, leading to variability in implementation and inconsistent outcomes.

Policy Recommendations and Interventions Based on Evidence from Multiple Contexts

Building upon the empirical evidence presented, several policy directions emerge as instrumental to strengthening the impact of school based iron supplementation programs. Firstly, integrating nutrition education into formal school curricula can improve adolescent understanding of anemia and its consequences. Education facilitates informed decision making and has the potential to reshape health behaviors over time. Sanghvi et al. (2023) have shown that culturally tailored education significantly improves adherence rates by making interventions more relatable and acceptable (Sanghvi et al., 2023).

Secondly, enhancing community involvement, particularly by engaging parents and local leaders, fosters a culture of shared responsibility. As demonstrated in Burkina Faso (Compaoré et al., 2018),

community buy in correlates with increased compliance and reduced stigma. Public awareness campaigns can dispel misconceptions surrounding iron supplementation and encourage proactive health seeking behaviors.

Thirdly, peer support networks offer a viable strategy to boost compliance. Students who receive reminders and encouragement from classmates are more likely to adhere to their supplementation regimen. This social model can be institutionalized through school clubs or student health councils that promote a collective sense of accountability.

Fourth, ensuring a consistent and accessible supply of supplements is crucial. Governments should invest in logistics infrastructure and digital inventory tracking systems that mitigate stock outs and delivery delays. Arënliu et al. (2019) emphasized that supply consistency is often the linchpin of successful intervention (Arënliu et al., 2019).

Additionally, a multi sectoral approach remains indispensable. Collaboration among ministries of health, education, and nutrition fosters integrated program delivery and maximizes resource efficiency. Examples from Ghana and India affirm that such alliances support broader coverage and long term viability. These partnerships also enable aligned messaging and comprehensive intervention strategies that address iron deficiency from multiple angles.

Regular monitoring and evaluation are necessary to ensure program responsiveness and effectiveness. By institutionalizing monitoring frameworks, policymakers can continuously improve implementation strategies based on real time data and health outcomes. Evaluation metrics should include hemoglobin levels, adherence rates, cognitive performance, and student feedback to ensure a holistic understanding of program impact.

Lastly, policies should be flexible and adaptive to local contexts. Variability in anemia prevalence, dietary habits, and cultural attitudes necessitates tailored interventions. Rather than applying a uniform model, policymakers should use local data to guide program design and adjust components to reflect ground realities.

This review is limited by the availability of high quality longitudinal studies that comprehensively track both adherence and educational outcomes over time. While many studies document short term improvements in hemoglobin levels, fewer explore long term academic and health trajectories. Moreover, regional differences in data availability and language barriers may have restricted the inclusion of relevant non English sources. These limitations point to the need for more consistent global reporting standards and expanded research efforts in underrepresented regions. Future reviews could benefit from incorporating primary qualitative data to better capture the lived experiences and perceptions of adolescent participants.

The findings of this review underscore the need for more integrated, community based, and context specific interventions in addressing iron deficiency anemia among adolescents. There is a strong

imperative for governments and international organizations to invest in cross sector collaboration and innovation in health education. Future research should focus on longitudinal impacts of supplementation, the effectiveness of digital adherence tools, and culturally sensitive strategies to enhance program ownership. Expanding the evidence base in these areas will contribute to more resilient health systems and improved adolescent well being globally.

CONCLUSION

This narrative review highlights the significant benefits of school based iron supplementation programs in improving the health and academic performance of adolescent girls, particularly in low and middle income countries. The findings reveal that both daily and weekly iron and folic acid supplementation can lead to notable increases in hemoglobin and serum ferritin levels, with daily regimens showing superior outcomes in some contexts. Adherence remains a critical challenge, influenced by factors such as gastrointestinal side effects, cultural perceptions, inadequate parental and peer support, and inconsistent supplement availability. Systemic barriers, including weak policy frameworks, logistical limitations, and fragmented stakeholder engagement, further complicate implementation.

The review emphasizes the need for integrated strategies that address these challenges through school based education, peer support systems, community involvement, and robust policy alignment across sectors. It also underscores the vital role of cognitive and academic improvements linked to better iron status, reinforcing the importance of such programs in enhancing long term educational outcomes. To advance these efforts, future research should prioritize longitudinal evaluations of adherence, cognitive impacts, and implementation strategies tailored to local contexts. Policymakers should focus on multi sectoral coordination, consistent supply chains, and culturally sensitive education campaigns. Overall, school based iron supplementation represents a promising and necessary intervention for tackling iron deficiency anemia, with implications for both public health and educational equity.

REFERENCES

Abou, K. (2023). Anemia: Prevalence and Characteristics Among Koranic School Children in Dakar, Senegal. *Hematology and Disorders*, *1*(1), 01–06. https://doi.org/10.58489/2836-3582/005

Adler, M., Herrera-Gómez, F., Martín-García, D., Gavid, M., Alvarez, E., & Sangrador, C. O. (2020). The Impact of Iron Supplementation for Treating Anemia in Patients With Chronic Kidney Disease: Results From Pairwise and Network Meta-Analyses of Randomized Controlled Trials. *Pharmaceuticals*, *13*(5), 85. https://doi.org/10.3390/ph13050085

Aggarwal, A., Aggarwal, A., Goyal, S., & Aggarwal, S. (2020). Iron-Deficiency Anemia Among Adolescents: A Global Public Health Concern. *International Journal of Advanced Community Medicine*, *3*(2), 35–40. https://doi.org/10.33545/comed.2020.v3.i2a.148

Alami, A., Hosseini, Z., Tehrani, H., & Jafari, A. (2020). *Evaluation of the Iron Aid Program Process in Iranian Girls' High School: A National Study*. https://doi.org/10.21203/rs.3.rs-16013/v1

Alizadeh, L., & Salehi, L. (2016). Is Routine Iron Supplementation Necessary in Pregnant Women With High Hemoglobin? *Iranian Red Crescent Medical Journal*, *18*(1). https://doi.org/10.5812/ircmj.22761

Arënliu, A., Strohmeier, D., Konjufca, J., Yanagida, T., & Burger, C. (2019). Empowering the Peer Group to Prevent School Bullying in Kosovo: Effectiveness of a Short and Ultra-Short Version of the ViSC Social Competence Program. *International Journal of Bullying Prevention*, *2*(1), 65–78. https://doi.org/10.1007/s42380-019-00052-4

Bahati, Y., Nyanza, E. C., Asori, M., Mutayoba, R., & Thomas, D. S. (2023). Influence of Intermittent Iron and Folic Acid Supplementation on Cognitive Abilities Among Adolescent Girls in Northwestern Tanzania. *Plos Global Public Health*, *3*(10), e0002079. https://doi.org/10.1371/journal.pgph.0002079

Bidwalker, S., & Sridevi, G. (2024). Unveiling the Impact of Homoeopathic Treatment on Iron Deficiency Anemia &Amp; It's Cognitive Function: A Closer Look at Adolescent Girls Through Moca Scale. *International Journal of Homoeopathic Sciences*, *8*(2), 21–23. https://doi.org/10.33545/26164485.2024.v8.i2a.1115

Chaparro, C. M., & Suchdev, P. S. (2019). Anemia Epidemiology, Pathophysiology, and Etiology in Low- and Middle-income Countries. *Annals of the New York Academy of Sciences*, *1450*(1), 15–31. https://doi.org/10.1111/nyas.14092

Chen, Z., Yang, H., Wang, D., Sudfeld, C. R., Zhao, A., Xin, Y., Chen, J., Fawzi, W., Xing, Y., & Li, Z. (2022). Effect of Oral Iron Supplementation on Cognitive Function Among Children and Adolescents in Low- And Middle-Income Countries: A Systematic Review and Meta-Analysis. *Nutrients*, *14*(24), 5332. https://doi.org/10.3390/nu14245332

Compaoré, A., Gies, S., Brabin, B. J., Tinto, H., & Brabin, L. (2018). Community Approval Required for Periconceptional Adolescent Adherence to Weekly Iron and/or Folic Acid Supplementation: A Qualitative Study in Rural Burkina Faso. *Reproductive Health*, *15*(1). https://doi.org/10.1186/s12978-018-0490-y

Daba, D. D., Bidu, K. T., Heyi, S. K., Garoma, D., & Assegu, Y. B. (2024). Compliance With Weekly Iron Folic Acid Supplementation and Associated Factors Among Secondary School Adolescent Girls, in Jimma Arjo District, West Ethiopia, 2022: A Mixed Method Cross-Sectional Study.

World Journal of Biology Pharmacy and Health Sciences, *20*(1), 394–408. https://doi.org/10.30574/wjbphs.2024.20.1.0800

Feriyanti, A., Deviatin, N. S., Nurmala, I., Widati, S., & Atmaka, D. R. (2022). Determinant of Adherence to Iron Supplementation in Adolescent Girl in Spesific Intervention for Stunting Prevention: Systematic Review. *Media Gizi Indonesia*, *17*(1SP), 90–96. https://doi.org/10.20473/mgi.v17i1sp.90-96

Ge, S., Ali, S., Haldane, V., Bekdache, C., Tang, G. H., & Sholzberg, M. (2023). An Approach to Hemequity: Identifying the Barriers and Enablers of Iron Deficiency Reduction Strategies in Low-to-Middle-Income Countries. *Blood*, *142*(Supplement 1), 367–367. https://doi.org/10.1182/blood-2023-181402

Gosdin, L., Sharma, A. J., Tripp, K., Amoaful, E. F., Mahama, A. B., Selenje, L., Jefferds, M. E., Martorell, R., Ramakrishnan, U., & Addo, O. Y. (2021). A School-Based Weekly Iron and Folic Acid Supplementation Program Effectively Reduces Anemia in a Prospective Cohort of Ghanaian Adolescent Girls. *Journal of Nutrition*, *151*(6), 1646–1655. https://doi.org/10.1093/jn/nxab024

Gosdin, L., Sharma, A. J., Tripp, K., Amoaful, E. F., Mahama, A. B., Selenje, L., Jefferds, M. E., Ramakrishnan, U., Martorell, R., & Addo, O. Y. (2020). Barriers to and Facilitators of Iron and Folic Acid Supplementation Within a School-Based Integrated Nutrition and Health Promotion Program Among Ghanaian Adolescent Girls. *Current Developments in Nutrition*, *4*(9), nzaa135. https://doi.org/10.1093/cdn/nzaa135

Hasan, M. M., Magalhães, R. J. S., Garnett, S. P., Fatima, Y., Tariqujjaman, Md., Pervin, S., Ahmed, S., & Mamun, A. A. (2022). Anaemia in Women of Reproductive Age in Low- And Middle-Income Countries: Progress Towards the 2025 Global Nutrition Target. *Bulletin of the World Health Organization*, *100*(03), 196–204. https://doi.org/10.2471/blt.20.280180

Hidayanty, H., Hasan, N., Irmayanti, I., Yuliana, Y., & Helmizar, H. (2024). *Perceived Barriers and Enablers to Take Iron Supplementation Regularly Among Adolescent Girls in Indonesia*. https://doi.org/10.20944/preprints202409.2318.v1

Hirosawa, T., Hayashi, A., Harada, Y., & Shimizu, T. (2022). The Clinical and Biological Manifestations in Women With Iron Deficiency Without Anemia Compared to Iron Deficiency Anemia in a General Internal Medicine Setting: A Retrospective Cohort Study. *International Journal of General Medicine*, *Volume 15*, 6765–6773. https://doi.org/10.2147/ijgm.s376405

Htet, M. K., Fahmida, U., Dillon, D., Akib, A. A., Utomo, B., & Thurnham, D. I. (2019). Is Iron Supplementation Influenced by Sub-Clinical Inflammation?: A Randomized Controlled Trial Among Adolescent Schoolgirls in Myanmar. *Nutrients*, *11*(4), 918. https://doi.org/10.3390/nu11040918

Isnaini, Y. S., Pihahey, P. J., Mintaningtyas, S. I., Simanjuntak, M. K., & Fabanjo, I. J. (2024). Knowledge, Attitude, Practice and Compliance to Weekly Iron Supplementation Among Female Public Junior High School Students in West Papua. *Public Health of Indonesia*, *10*(4), 38–48. https://doi.org/10.36685/phi.v10i4.858

Jalambo, M. O., Karim, N. A., Naser, I. A., & Sharif, R. (2018). Effects of Iron Supplementation and Nutrition Education on Haemoglobin, Ferritin and Oxidative Stress in Iron-Deficient Female Adolescents in Palestine: Randomized Control Trial. *Eastern Mediterranean Health Journal*, *24*(6), 560–568. https://doi.org/10.26719/2018.24.6.560

Keats, E. C., Neufeld, L. M., Garrett, G., Mbuya, M. N. N., & Bhutta, Z. A. (2019). Improved Micronutrient Status and Health Outcomes in Low- And Middle-Income Countries Following Large-Scale Fortification: Evidence From a Systematic Review and Meta-Analysis. *American Journal of Clinical Nutrition*, *109*(6), 1696–1708. https://doi.org/10.1093/ajcn/nqz023

Khammarnia, M., Amani, Z., Hajmohammadi, M., Ansari-Moghaddam, A., & Eslahi, M. (2016). A Survey of Iron Supplementation Consumption and Its Related Factors in High School Students in Southeast Iran, 2015. *Malaysian Journal of Medical Sciences*, *23*(5), 57–64. https://doi.org/10.21315/mjms2016.23.5.8

Kore, S., Pawar, S., Jadhao, M., & Kukade, R. (2022). Effect of Iron and Folic Acid Supplementation Among Nutritionally Anemic Women of Reproductive Age in Rural Maharashtra: Acommunity-Based Intervention Study. *Bharati Vidyapeeth Medical Journal*, *2*(4), 14–18. https://doi.org/10.56136/bvmj/2022_00090

Kumar, V., Kumar, M., & Sahni, G. S. (2020). An Experimental Study to Determine the Effect of Iron Supplement in Cognitive Enhancement in Children. *International Journal of Medical and Biomedical Studies*, *4*(4). https://doi.org/10.32553/ijmbs.v4i4.1357

Mabrouk, A., Khamis, M. K., Meabed, M., & Elkareem, R. A. (2022). Iron Deficiency Anemia in Primary School Children in Beni-Suef (Prevalence and Clinical Spectrum). *Egyptian Journal of Medical Research*, *3*(3), 41–55. https://doi.org/10.21608/ejmr.2022.252258

Mahundi, P., Pillay, K., & Wiles, N. (2021). Barriers to Optimal Iron Supplementation by Pregnant Women Attending the Mutare City Clinic, Manicaland, Zimbabwe. *Africa Journal of Nursing and Midwifery*, *23*(1). https://doi.org/10.25159/2520-5293/6948

Manikam, N. R. M. (2021). Known Facts: Iron Deficiency in Indonesia. *World Nutrition Journal*, *5*(S1), 1–9. https://doi.org/10.25220/wnj.v05.s1.0001

Miranda, V. I. A., Pizzol, T. da S. D., Silveira, M. P. T., Mengue, S. S., Silveira, M. F. d., Lutz, B. H., & Bertoldi, A. D. (2019). The Use of Folic Acid, Iron Salts and Other Vitamins by Pregnant Women in the 2015 Pelotas Birth Cohort: Is There Socioeconomic Inequality? *BMC Public Health*, *19*(1). https://doi.org/10.1186/s12889-019-7269-0

Munira, L., & Viwattanakulvanid, P. (2024). Knowledge, Attitude, and Practice Towards Anemia Prevention Among Female Students in Indonesia: A Mixed Method Study. *International Journal of Evaluation and Research in Education (Ijere)*, *13*(1), 371. https://doi.org/10.11591/ijere.v13i1.25750

Mwakishalua, J., Karanja, S., Lihana, R., Okoyo, C., Stoffel, N. U., & Zimmermann, M. (2024). Prevalence and Predictors of Anemia Among Six-Week-Old Infants in Kwale County, Kenya: A Cross-Sectional Study. *Plos Global Public Health*, *4*(3), e0003062. https://doi.org/10.1371/journal.pgph.0003062

Nampijja, M., Mutua, A. M., Elliott, A. M., Muriuki, J. M., Abubakar, A., Webb, E. L., & Atkinson, S. H. (2022). Low Hemoglobin Levels Are Associated With Reduced Psychomotor and Language Abilities in Young Ugandan Children. *Nutrients*, *14*(7), 1452. https://doi.org/10.3390/nu14071452

Nayina, I. B. R., Kogi, R., Ndayishimiye, J. C., & Opoku, S. Y. (2024). *Assessment of the Implementation of Iron and Folic Acid Tablets Supplementation to in-School Girls in Nanumba South District of Northern Region, Ghana*. https://doi.org/10.1101/2024.11.26.24317998

Neuberger, A., Okebe, J., Yahav, D., & Paul, M. (2016). Oral Iron Supplements for Children in Malaria-Endemic Areas. *Cochrane Database of Systematic Reviews*, *2016*(2). https://doi.org/10.1002/14651858.cd006589.pub4

Pattrakornkul, N., Ngamcherdtrakul, P., Kriangburapa, W., Tangjaturonrasme, S., & Yampratoom, R. (2021). *A Randomized Controlled Trial of Daily and Weekly Iron Supplementations for Improving Iron Status in the Infants*. https://doi.org/10.21203/rs.3.rs-310880/v1

Paulino, C. T. da S., Nishijima, M., & Sarti, F. M. (2021). Association of Iron Supplementation Programs With Iron-Deficiency Anemia Outcomes Among Children in Brazil. *Nutrients*, *13*(5), 1524. https://doi.org/10.3390/nu13051524

Putri, S. Z., Budu, B., Gemini, G., & Natsir, R. (2021). Non-Pharmacological Interventions for Anemia Treatment: Systematic Review. *Muhammadiyah International Public Health and Medicine Proceeding*, *1*(1), 283–312. https://doi.org/10.53947/miphmp.v1i1.56

Rahayu, D. E., Yudhani, R. D., Kusumawati, R., & Indarto, D. (2017). *Iron Deficiency Is the Main Cause of Anemia in Female Students of Secondary Schools in Sukoharjo Regency With No Polymorphism of Transferrin Receptor 1*. https://doi.org/10.2991/ichlas-17.2017.41

Riddle, A., Kroeger, C. M., Ramage, A. K., Bhutta, Z. A., Kristjansson, E., Vlassoff, C., Taljaard, M., Skidmore, B., Welch, V., & Wells, G. A. (2019). PROTOCOL: The Effects of Empowerment-based Nutrition Interventions on the Nutritional Status of Adolescent Girls in Low- and Middle-income Countries. *Campbell Systematic Reviews*, *15*(3). https://doi.org/10.1002/cl2.1042

Roque, J. (2023). Revisiting the Level of School-Based Management in Public Elementary Schools of Santiago City, Isabela, Philippines. *Jett*, *14*(1). https://doi.org/10.47750/jett.2023.14.01.012

Salam, R. A., Hooda, M., Das, J. K., Arshad, A., Lassi, Z. S., Middleton, P., & Bhutta, Z. A. (2016). Interventions to Improve Adolescent Nutrition: A Systematic Review and Meta-Analysis. *Journal of Adolescent Health*, *59*(4), S29–S39. https://doi.org/10.1016/j.jadohealth.2016.06.022

Samson, K. L. I., Fischer, J. A. J., & Roche, M. (2022). Iron Status, Anemia, and Iron Interventions and Their Associations With Cognitive and Academic Performance in Adolescents: A Systematic Review. *Nutrients*, *14*(1), 224. https://doi.org/10.3390/nu14010224

Sanghvi, T., Nguyen, P. H., Forissier, T., Ghosh, S., Zafimanjaka, M., Walissa, T., Mahmud, Z., & Kim, S. S. (2023). Comprehensive Approach for Improving Adherence to Prenatal Iron and Folic Acid Supplements Based on Intervention Studies in Bangladesh, Burkina Faso, Ethiopia, and India. *Food and Nutrition Bulletin*, *44*(3), 183–194. https://doi.org/10.1177/03795721231179570

Saydam, B. K. (2017). The Effect of Variables Related to Reproductivity on Anemia Detected in Women. *Pakistan Journal of Medical Sciences*, *33*(2). https://doi.org/10.12669/pjms.332.11771

Schultz, L., Renaud, A., Bundy, D. A. P., Barry, F. B., Benveniste, L., Lara, C. B. d., Lô, M. M., Neitzel, J., O'Grady, N., & Drake, L. (2024). The SABER School Feeding Policy Tool: A 10-Year Analysis of Its Use by Countries in Developing Policies for Their National School Meals Programs. *Frontiers in Public Health*, *12*. https://doi.org/10.3389/fpubh.2024.1337600

Sedlander, E., Long, M. W., Mohanty, S., Munjral, A., Bingenheimer, J. B., Yilma, H., & Rimal, R. N. (2019). *Moving Beyond Individual Barriers and Identifying Multi-Level Strategies to Reduce Anemia in Odisha India*. https://doi.org/10.21203/rs.2.10937/v1

Shaban, L., Al-Taiar, A., Rahman, A., Al-Sabah, R., & Mojiminiyi, O. A. (2020). Anemia and Its Associated Factors Among Adolescents in Kuwait. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-60816-7

Silva-Neto, L. G. R., Neto, J. E. dos S., Bueno, N. B., Oliveira, S. L. d., & Ataíde, T. d. R. (2018). Effects of Iron Supplementation Versus Dietary Iron on the Nutritional Iron Status: Systematic Review With Meta-Analysis of Randomized Controlled Trials. *Critical Reviews in Food Science and Nutrition*, *59*(16), 2553–2561. https://doi.org/10.1080/10408398.2018.1459469

Sudfeld, C. R., Kumar, R., Barik, A., Valadez, J. J., & Fawzi, W. (2020). Population-Level Effective Coverage of Adolescent Weekly Iron and Folic Acid Supplementation Is Low in Rural West Bengal, India. *Public Health Nutrition*, *23*(15), 2819–2823. https://doi.org/10.1017/s1368980020000932

Vidal, C., Kezar, A., Platt, R., Owczarzak, J., & Hammond, C. J. (2024). School-Based Screening and Brief Intervention for Adolescent Substance Use With Telehealth-Delivered Case Consultation and Education. *Substance Use & Addiction Journal*. https://doi.org/10.1177/29767342241241399

Williams, A. M., Guo, J., Addo, O. Y., Ismaily, S., Namasté, S., Oaks, B. M., Rohner, F., Suchdev, P. S., Young, M., Flores-Ayala, R., & Engle-Stone, R. (2020). Intraindividual Double Burden of Overweight or Obesity and Micronutrient Deficiencies or Anemia Among Women of Reproductive Age in 17 Population-Based Surveys. *American Journal of Clinical Nutrition*, *112*, 468S-477S. https://doi.org/10.1093/ajcn/nqaa118

Wisnuwardani, R. W., Wulandari, S., & Kartika, A. D. (2023). Health Education to Prevent Anemia Among Adolescents in Samarinda, Indonesia. *Abdimas Jurnal Pengabdian Masyarakat Universitas Merdeka Malang*, *8*(2), 288–296. https://doi.org/10.26905/abdimas.v8i2.9224