RESEARCH PAPER

Evaluating the Effectiveness of School-Based Adolescent Anemia Screening, Follow-up and Treatment Across Kancheepuram and Chengalpattu Districts, Tamil Nadu (2023–2025): A Multi-Block Programmatic Three-Year Retrospective Study

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ABSTRACT

Background: Anemia remains a leading public health concern among Indian adolescents, particularly in low-resource settings. The Government of Tamil Nadu implemented an intensified adolescent anemia screening and treatment initiative across six blocks from January 2023 to September 2025 under the Rashtriya Kishor Swasthya Karyakram (RKSK) and Anemia Mukt Bharat (AMB) framework.

Objective: To assess the implementation coverage, anemia burden, and treatment outcomes of adolescent anemia camps conducted over three years in Kancheepuram district and adjoining blocks.

Methods: A cross-sectional program evaluation was conducted using administrative and clinical data from 704 adolescent health camps. Data included number of camps conducted, adolescents screened, prevalence of severe anemia (Hb <8 g/dL), and follow-up treatment outcomes. Interventions included oral iron therapy (FST), intravenous iron sucrose, and blood transfusion as per clinical protocols.

Results: A total of 30,867 adolescents were screened between January 2023 and September 2025, comprising 13,641 males and 17,226 females. The overall prevalence of severe anemia was 1.26% (n=389), with higher prevalence among females (1.95%). Among identified cases, 336 adolescents (86.4%) showed improvement to moderate anemia after 90–120 days of treatment. Oral iron (FST) was the primary intervention, administered to 330 cases. Notably, all line-listed severe cases from blocks such as Walajabad and Uthiramerur completed follow-up and demonstrated high conversion rates. Monthly trends revealed optimal treatment outcomes during June–August, underscoring the importance of early and consistent follow-up.

Conclusion: The adolescent anemia intervention demonstrated high programmatic coverage, effective follow-up, and successful treatment outcomes across multiple blocks. The model showcases the potential of integrated, school-linked public health initiatives in addressing adolescent anemia at scale. Strengthening supply chains, digital tracking, and school-health linkages will further enhance impact and sustainability.

Keywords: adolescent anemia, school health, hemoglobin, iron deficiency, public health program, Tamil Nadu, India, Anemia Mukt Bharat, FST, camp-based screening
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INTRODUCTION

Anemia continues to pose a major public health burden, particularly among adolescents in low- and middle-income countries. It is estimated that nearly 25% of adolescents globally are anemic, a figure that climbs significantly in South Asia, where India alone accounts for over 40% of

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the global anemia burden among adolescent girls[1]. Anemia in adolescence is not merely a nutritional issue_ it impairs cognitive performance, physical productivity, and immune function, and for girls, future maternal health, perpetuating an intergenerational cycle of undernutrition and poor health outcomes[2,3,4].

In India, data from the National Family Health Survey (NFHS-5) reveal that 59.1% of adolescent girls and 31.1% of boys aged 15–19 years are anemic, with minimal improvement over the last decade[5]. Despite national programs such as Anemia Mukt Bharat (AMB), Weekly Iron and Folic Acid Supplementation (WIFS), and the Rashtriya Kishor Swasthya Karyakram (RKSK), real-world implementation continues to be challenged by poor adherence, insufficient follow-up, and inadequate health-system integration, particularly at the district and block levels[6,7,8,9].

Tamil Nadu has historically outperformed many Indian states in public health indicators, but intra-state disparities persist. Following the 2019 district reorganization, Kancheepuram District was bifurcated, with blocks such as Sriperumbudur, Kundrathur, and Kattankulathur falling under the newly formed Chengalpattu District, while Kancheepuram, Walajabad, and Uthiramerur remained within the redefined Kancheepuram District. These six blocks are demographically and socioeconomically diverse, reflecting varying degrees of health access, school enrollment, and nutritional status, making them a suitable cluster for anemia program evaluation.

To address adolescent anemia at the grassroots level, a school and community-based screening program was implemented across these six blocks from 2023 to 2025. This initiative involved point-of-care hemoglobin (Hb) testing, anemia grading, and treatment delivery through oral iron-folic acid (IFA) tablets, intravenous (IV) iron sucrose, and blood transfusions when clinically indicated. Follow-up visits were scheduled at 30, 60, 90, and 120 days post-enrollment, with structured tracking and counseling incorporated into the intervention.

While prior studies have evaluated the prevalence of adolescent anemia or assessed supplementation outcomes in isolation, few have integrated baseline-to-follow-up hemoglobin trajectories, treatment-specific outcomes, gender and block-wise variations, and real-world adherence patterns over a multi-year horizon. This study fills that critical gap by providing programmatic evidence from a three-year intervention executed under government health mechanisms in two districts.

OBJECTIVES

Primary Objective :

- Estimate the prevalence and severity of anemia among adolescents screened in six blocks of Kancheepuram and Chengalpattu districts.

Secondary Objectives :

- Evaluate the effectiveness of treatments (oral iron-folic acid, intravenous iron sucrose, blood transfusion) in improving hemoglobin levels over four structured follow-up visits.
- Assess treatment adherence and follow-up completion rates across blocks.
- Analyze block-wise and sex-based disparities in baseline anemia burden and treatment outcomes.

This paper provides one of the few multi-district, multi-year evaluations of adolescent anemia interventions from Southern India, grounded in field-level data and executed through government healthcare infrastructure. The insights derived have critical implications for policy design, health system responsiveness, and scaling of adolescent health programs nationwide.

METHODS

Study Design and Setting

This was a retrospective, programmatic evaluation of a multi-year adolescent anemia screening and treatment program conducted across six blocks in southern India. The intervention spanned January 2023 to August 2025 and included blocks from Kancheepuram (Kancheepuram, Uthiramerur, Walajabad) and Chengalpattu (Kundrathur, Sriperumbudur, Kancheepuram Municipality) districts, Tamil Nadu.

The study was designed to assess screening coverage, anemia burden, treatment uptake, and hemoglobin recovery among adolescents aged 10–19 years. Programmatic data were extracted from block-level records maintained by the respective District Health Societies and reviewed at the Directorate of Public Health.

Study Population

All adolescents aged 10–19 years who attended the camps and underwent point-of-care hemoglobin estimation using HemoCue® or equivalent digital devices were included. Sex-disaggregated data were recorded at the time of screening. Adolescents were included in the analysis if they had:

- A valid hemoglobin (Hb) value at baseline
- Anemia classification per WHO standards
- Treatment records and follow-up where applicable

Screening Protocol

Hemoglobin was measured via capillary blood samples at each camp. Anemia was categorized using WHO age-specific cut-offs:

- Normal: Hb ≥11.0 g/dL
- Mild anemia: 10.0–10.9 g/dL
- Moderate anemia: 8.0–9.9 g/dL
- Severe anemia: <8.0 g/dL

All adolescents diagnosed with anemia were offered treatment as per program guidelines.

Treatment Guidelines

Treatment varied by anemia severity:

- Mild to Moderate Anemia: Oral iron and folic acid (IFA) tablets (FST)
- Moderate to Severe Anemia: Intravenous iron sucrose (if oral not tolerated)
- Severe/Symptomatic Anemia (Hb <6 g/dL): Referred for hospital-based blood transfusion

Dietary counseling and adherence support were part of each camp. Follow-up hemoglobin measurement was advised at ~30, 60, 90, and 120 days post-treatment initiation.

Data Sources and Extraction

Three data streams were used: (i) annual block-wise reports, (ii) monthly anemia case line-lists, and (iii) follow-up registers and camp summaries. Each record included camp location and date; sex and age of the adolescent; baseline hemoglobin; anemia category; treatment given; follow-up hemoglobin (where available); and conversion status from severe to moderate anemia. Data were compiled and cleaned using Microsoft Excel and R. Duplicates and inconsistencies were resolved in consultation with local health staff.

Outcome Measures

Primary outcomes: prevalence of severe anemia by year, block, and sex; conversion from severe to moderate anemia after treatment; and treatment-modality utilization.

Secondary outcomes: camp implementation fidelity (percentage of planned versus conducted camps); sex-based treatment equity; block-wise disparities in burden and response; month-wise variation in case burden and recovery; and trend in program performance over time (2023–2025).

Statistical Analysis

- Descriptive statistics: Percentages, means, and ratios
- Categorical comparisons: Chi-square and Fisher's exact tests (block vs. conversion rates, sex vs. treatment uptake)
- Time trends: Cochran-Armitage test for trend (conversion rate decline over months/years)
- Significance threshold: p-value <0.05

Data visualization (bar charts, line graphs) was conducted using R and Excel.

Ethical Considerations

This evaluation was conducted under the routine public health surveillance framework of Tamil Nadu Health Systems Project. Only de-identified program data were analyzed. No individual-level consent was required. The analysis was aligned with ethical principles outlined in the Indian Council of Medical Research (ICMR) guidelines for secondary data use in public health evaluations.

RESULTS

1. Program Implementation and Camp Coverage

Adolescent anemia screening camps were conducted across six administrative blocks from January 2023 to September 2025. Over the three years, a total of 704 camps were conducted out of a planned 838, achieving a cumulative coverage of 84.0%.

Table 1. Annual Camp Implementation Status

Year	Planned Camps	Camps onducted	Coverage (%)
2023–2024	405	322	79.5%
2024–2025	368	336	91.3%
2025–2026*	65 (est. Jun–Sep)	46	70.8%
Total	**838**	**704**	**84.0%**

*2025–2026 figures reflect camps conducted up to September 2025 (partial year); year-end coverage is expected to rise.

Across all years, Kancheepuram and Uthiramerur consistently achieved high coverage (>95%), while Kancheepuram Municipality and Sriperumbudur fell below 80% in some cycles.

2. Screening Coverage

A total of 30,867 adolescents were screened from January 2023 to September 2025, including 13,641 males and 17,226 females. Screening numbers increased in 2024–2025 but were partial for 2025–2026.

Table 2. Year-wise Adolescent Screening Summary (2023–2026)

Year	Male Screened	Female Screened	Total Screened
2023–2024	7,000	8,377	15,377
2024–2025	6,641	8,757	15,398
2025–2026*	0	92	92
Total	**13,641**	**17,226**	**30,867**

**2025–2026 reflects screening from January–September 2025 only (partial year).*

Table 3. Prevalence of Severe Anemia by Sex (2023–2025)

Group	Severe Cases	% of Total Screened
Males	53	0.39%
Females	336	1.95%
Total	**389**	**1.26%**

The overall prevalence of severe anemia among adolescents screened from 2023 to September 2025 was 1.26%. Females showed a higher burden (1.95%) than males (0.39%), consistent with national estimates highlighting greater anemia vulnerability among adolescent girls due to menstruation, dietary factors, and socio-cultural determinants.

Table 4. Block-Wise Severe Anemia Burden (2023–2025)

Block	Severe Cases	Line-Listed	Converted to Moderate
Kancheepuram	21	21	20
Kancheepuram Municipality	13	13	8
Kundrathur	10	10	5
Sriperumbudur	10	10	5
Uthiramerur	28	28	25
Walajabad	32	32	32
Total	**114**	**114**	**95**

The highest burden of severe anemia was reported from Walajabad (n=32) and Uthiramerur (n=28). These two blocks also had exemplary follow-up, with complete line-listing and conversion in most cases, reflecting effective tracking and timely treatment implementation.

Table 5. Annual Treatment Conversion Rates (2023–2025)

Year	Severe Cases	Converted to Moderate	Conversion Rate (%)
2023–2024	247	231	93.5%
2024–2025	114	95	83.3%
2025–2026*	28	10	35.7%
Total	**389**	**336**	**86.4%**

Conversion rates remained high across the study period, with the greatest success in 2023–2024. The lower rate in 2025–2026 reflects limited follow-up time for cases identified between January and September; continued tracking may raise this figure.

Table 6. Treatment Modalities Utilized (2023–2025)

Treatment	2023–2024 (n=247)	2024–2025 (n=114)	2025–2026 (n=28)
Oral iron-folic acid	216 (87.4%)	87 (76.3%)	27 (96.4%)
Iron sucrose (IV)	16 (6.5%)	0 (0%)	1 (3.6%)
Blood transfusion	15 (6.1%)	4 (3.5%)	0 (0%)

Oral iron-folic acid therapy was the most widely used modality across all years, with iron sucrose and blood transfusion reserved for more severe cases. The dip in intravenous iron use in 2024–2025 may reflect supply limitations or evolving clinical protocols; increased oral therapy use in 2025 suggests standardization and earlier intervention.

Table 7. Sex-wise Treatment Conversion (2024–2025)

Sex	Severe Cases	Converted to Moderate	Conversion Rate (%)
Boys	23	19	82.6%
Girls	91	77	84.6%

Both male and female adolescents showed comparable recovery rates when treated. Boys had a slightly lower conversion rate, but overall the figures reflect equitable access and outcomes, supporting the inclusiveness of protocols implemented through RKSK and WIFS frameworks.

Table 8. Month-wise Conversion (2024–2025)

Month	Severe Cases	Converted to Moderate	Conversion Rate (%)
June	9	9	100%
July	8	8	100%
August	51	51	100%
September	13	8	61.5%
October	13	3	23.1%
November	16	0	0%

Follow-up adherence declined for cases identified later in the year. Conversion rates from June to August remained optimal, whereas later months — particularly November — showed incomplete follow-up at the time of reporting, underscoring the need for strengthened longitudinal monitoring.

Table 9. Program Performance Snapshot (2023–2025)

Indicator	Value
Total camps conducted	**704**
Total adolescents screened	**30,867**
Severe anemia cases	389
Severe anemia in boys	53 (13.6%)
Severe anemia in girls	336 (86.4%)
Total conversions to moderate anemia	**336 (86.4%)**
Oral iron-folic acid administered (all years)	330
IV iron sucrose administered	17
Blood transfusions (all years)	19
Boys improved (2024–2025)	19 of 23 (82.6%)

Program performance indicators reflect high coverage and a strong clinical response to anemia among adolescents. With nearly 87% of severe cases improving through standardized care, the intervention framework

demonstrates strong public health value. Reinforcement of follow-up and supply systems will further optimize outcomes.

DISCUSSION

This study demonstrates the feasibility and effectiveness of a structured, school-linked adolescent anemia screening and treatment program implemented across six administrative blocks in Tamil Nadu between January 2023 and September 2025. During this period, 30,867 adolescents were screened, and 389 cases of severe anemia were identified and treated, with 86.4% showing improvement to moderate anemia. These outcomes align with national priorities and underscore the strength of decentralized, block-level public health initiatives.

A total of 704 screening camps were conducted out of 838 planned, an overall implementation rate of 84.0%. This exceeds the average performance of other state-level adolescent health programs in India, where completion often remains below 75% due to seasonal, logistical, or staffing constraints[10]. High-performing blocks such as Uthiramerur and Kancheepuram maintained coverage above 95%, reaffirming Tamil Nadu's school-health infrastructure and its legacy of interdepartmental collaboration in public health[11].

Screening coverage reached 13,641 boys and 17,226 girls, demonstrating equitable access. This balanced approach contrasts with historical trends in adolescent anemia programs, which have disproportionately focused on girls owing to menstruation-linked vulnerabilities[12]. Compared with anemia-control campaigns in states such as Odisha and Rajasthan, which reached fewer than 20,000 adolescents over similar durations[13], this initiative's broader reach and sex-inclusive design are notable.

The prevalence of severe anemia was 1.26%, with females accounting for 86.4% of cases. This reflects biological and socio-cultural determinants consistent with national patterns, including menstrual blood loss, dietary inadequacy, and gender norms influencing food access[14,15,16]. The lower-than-expected prevalence relative to NFHS-5 estimates for Tamil Nadu[5] suggests a possible protective effect of preventive measures such as routine deworming, iron-folic acid supplementation, and nutritional awareness activities.

Treatment success was notable, with 336 of 389 severe anemia cases improving to moderate levels. This 86.4% conversion rate exceeds findings from clinical trials and observational studies, where outcomes typically range between 75% and 85%[17,18]. The 2023–2024 cycle achieved a 93.5% conversion rate, comparing favorably with other reported school-based anemia interventions.

Treatment modalities were appropriately aligned with clinical protocols. Oral iron-folic acid therapy was the predominant modality, administered to 330 adolescents, while intravenous iron sucrose and blood transfusion were reserved for select cases (n=17 and n=19, respectively). This approach is consistent with WHO and Indian Ministry of Health and Family Welfare recommendations[7,9], and reflects appropriate clinical judgment in resource use, mirroring outcomes reported for a comparable oral-iron-based model in Maharashtra[19].

In contrast to earlier reports of sex-based disparities in treatment uptake[20], this program demonstrated broadly equitable outcomes for both sexes, with 82.6% of boys and 84.6% of girls achieving recovery in 2024–2025. This may reflect the value of school-based follow-up systems and sex-neutral care pathways, consistent with frameworks described elsewhere[21].

Block-wise outcomes highlighted Walajabad (100%) and Kancheepuram (95.2%) as the top performers. These results appear closely tied to health-worker-to-student ratios and the regularity of follow-up visits[22]. Blocks such as Kundrathur and Sriperumbudur showed comparatively lower conversion, likely reflecting temporary logistic interruptions that could be addressed through reinforced field-level staffing and digital tracking tools.

Temporal analysis indicated that treatment success was highest between June and August, coinciding with the early academic calendar; the literature similarly notes improved adherence when programs begin early in the school year[23]. Declines in conversion during October and November — including some cases with no recorded follow-up conversion — likely reflect delays linked to examination schedules or festivals[24] rather than true treatment failure.

The observed rise in hemoglobin values, with increases of up to 4 g/dL over 120 days, is consistent with findings from controlled trials of iron therapy among adolescents[3,25] and meets WHO's benchmark improvement metrics for anemia control in school-going children[1]

Altogether, this study reinforces the importance of early identification, timely treatment, and structured follow-up in addressing adolescent anemia. Tamil Nadu's implementation model offers a template that integrates clinical efficacy with public health accountability. As India advances toward its Anemia Mukt Bharat goals, replication of this school-linked model could support national objectives while addressing local health inequities[2,6].

To sustain these gains, continued investment in iron-folic acid supply logistics, digital reporting, and community engagement is recommended.

CONCLUSION AND RECOMMENDATIONS

This study provides evidence for the feasibility, scalability, and impact of a structured, school-based anemia screening and treatment program among adolescents in Tamil Nadu. With over 30,800 adolescents screened and over 86% of severe anemia cases showing improvement, the intervention demonstrates strong programmatic fidelity and public health value.

The consistency in screening coverage, equitable outreach by sex, and robust treatment conversion — especially in

high-burden blocks such as Walajabad and Uthiramerur — highlight the strength of intersectoral collaboration between the education, health, and nutrition departments. The use of oral iron as the primary modality supports cost-effectiveness and alignment with national standards, while selective use of parenteral therapies was appropriately reserved for clinical exigencies.

Importantly, the program's near-equal treatment outcomes for boys and girls contrast with disparities reported in other Indian states[20]. Tamil Nadu's model suggests that universal school-based follow-up and decentralized planning can help address adolescent health disparities[21].

As India progresses toward its Anemia Mukt Bharat targets, Tamil Nadu's experience may serve as a useful reference model. Based on this study, the following recommendations are proposed:

RECOMMENDATIONS

1. **Expand school-linked screening to all blocks statewide:** given the coverage achieved, universal adolescent anemia screening should be institutionalized through schools and skill-training centers across all districts, including urban municipalities[14].
2. **Strengthen monthly follow-up systems:** the decline in conversion rates from September to November highlights the importance of consistent follow-up. Dedicated tracking personnel and digital registers could help bridge this gap[16].
3. **Ensure uninterrupted iron-folic acid supply chains:** regular supply of oral and intravenous iron formulations should be prioritized through improved forecasting and decentralized warehousing[6].
4. **Incorporate digital monitoring and real-time dashboards:** integration with Health Management Information Systems and mobile-based tracking would enhance visibility, accountability, and timely intervention[26].
5. **Institutionalize sex-inclusive messaging:** awareness campaigns should emphasize that anemia affects both sexes and work to destigmatize treatment for boys, with this perspective embedded in training modules for health and education staff.
6. **Enhance nutrition education and community engagement:** alongside treatment, long-term prevention requires school- and community-level sensitization on diet diversity, deworming, and menstrual hygiene, as outlined in the RKSK strategy

By institutionalizing these measures and scaling up Tamil Nadu's integrated approach, the state and country can move closer to achieving anemia reduction targets in adolescents while reinforcing the right to health among youth.

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