Jurnal Gizi dan Teknologi Pangan : Nutrismart
https://fikesunras.ac.id/index.php/NutriSmart
NutriSmart Vol 2(2) 2026 Pages 85-97

Prevalence and Determinants of Iron Deficiency Anaemia Among Pregnant Women and Adolescent Girls

Tara Verma✉[1], Diya Banerjee[2], Arjun[3]
Terav3@gmail.com, diyabanerjee@gmail.com, arjuncond@gmail.com
Department of Nutrition and Dietetics, Manav Rachna International Institute of Research and Studies, India

Article History:
Submitted and Pre-review: 14 June 2026
Review: 11 July 2026
Copy Edit: 28 July 2026
Production: 30 July 2026
Published: 31 July 2026

Doi: https://doi.org/10.64146/gd5ad854

Abstract

Anaemia remains a major public health challenge in India, with pregnant women and adolescent girls bearing a disproportionately high burden, yet population-based evidence comparing these two groups within the same high-burden states remains scarce. This study estimated the prevalence, severity, and determinants of anaemia among pregnant women (n=4,847) and adolescent girls aged 15–19 years (n=21,358) in Bihar and Uttar Pradesh using data from the fifth National Family Health Survey (NFHS-5, 2019–2021). A cross-sectional design was employed with multivariable binary logistic regression accounting for the complex survey design. Anaemia prevalence reached 63.1% among pregnant women and 63.5% among adolescent girls in Bihar, compared with 50.4% and 49.8% in Uttar Pradesh, respectively, yielding combined estimates of 54.6% and 54.2%. Moderate anaemia accounted for the largest share of the burden, particularly in Bihar. In both groups, low education, poverty, Scheduled Caste or Tribe status, and rural residence were independently associated with higher odds of anaemia. Among pregnant women, higher parity, short birth spacing, and incomplete iron-folic acid supplementation further elevated the risk. The shared social gradient across both groups supports a life-course approach that reaches adolescent girls before pregnancy, strengthens supplementation coverage, and targets the structural determinants concentrated in the most disadvantaged populations.

Keywords: Nutritional status, socio-economic determinants, reproductive-age women, public health intervention

How to cite this article:
Verma, tara, Banerjee, D. ., & Arjun. (n.d.). Prevalence and Determinants of Iron Deficiency Anemia Among Pregnant Women and Adolescent Girls in Bihar and Uttar Pradesh, India: A Population-Based Study. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 2(2), 85-97. https://doi.org/10.64146/gd5ad854

✉ Corresponding author:
Email Address: Tara Verma (Terav3@gmail.com)

e-issn: 3110-4959

INTRODUCTION

Iron deficiency anaemia is the most common micronutrient disorder worldwide, with women of reproductive age bearing a disproportionately high burden. Global estimates for 2019 placed anaemia among women of reproductive age at close to 30 percent, with pregnant women affected more often than their non-pregnant peers (Merid et al., 2023; World Health Organization, 2021).

South Asia is one of the worst-affected regions, and within it, India accounts for a large part of the absolute caseload. A recent systematic review and meta-analysis of Indian data reported a pooled anaemia prevalence of about 72 percent among pregnant women, far above the level seen in many other low- and middle-income settings (Jeevan et al., 2025). National survey data tell a similar story. Rather than falling, anaemia among Indian women rose between the fourth and fifth rounds of the National Family Health Survey, a reversal that has worried researchers and program managers alike (Chakrabarty et al., 2023; Jeevan et al., 2025).

Bihar and Uttar Pradesh bear the heaviest burden among Indian states. Together, they hold a substantial fraction of India's population, and both belong to the Empowered Action Group states that lag on most maternal and child health indicators. Together, the two states are home to more than 350 million people, so even modest differences in prevalence translate into millions of affected women (Kuppusamy et al., 2024). Analyses of the fifth survey round show that pregnant women in Bihar have the highest anaemia prevalence among India's large states, while several districts of Uttar Pradesh sit above the national average (Let et al., 2024). Work focused on Uttar Pradesh has documented wide gaps between urban and rural women and between literate and illiterate women, which point to deep social patterning rather than a uniform burden (Maheshwari et al., 2025).

Anaemia in these populations is driven primarily by iron deficiency, although other factors contribute. The Comprehensive National Nutrition Survey, the first national survey to measure biomarkers from venous blood, found that iron deficiency was the single strongest predictor of anaemia in adolescents and that adolescent girls were far more likely to be iron deficient than boys (Kulkarni et al., 2021; Ministry of Health et al., 2019; Sarna et al., 2020). Poor dietary diversity, low intake of iron-rich foods, menstrual losses, repeated pregnancies, and infections all add to the deficit, and nutritional strategies on their own rarely close the gap without attention to these wider causes (Cahyani, 2025; Harjadinta & Susanty, 2025; Rai et al., 2022). Defining anaemia in this context relies on haemoglobin thresholds set by the World Health Organization, which differ for pregnant and non-pregnant individuals.

In pregnancy, anaemia raises the risk of low birth weight, preterm delivery, and maternal complications, and a sizeable share of perinatal deaths in South Asia is attributable to it (Kuppusamy et al., 2024; Merid et al., 2023). For adolescents, iron deficiency and anaemia are linked to poorer attention, weaker school performance, and reduced work capacity. Iron-deficiency anaemia ranks among the leading causes of years lived with disability in this age band (Gutema et al., 2023; Samson et al., 2022). Trials of iron supplementation report gains in cognitive outcomes among children and young people, which strengthens the case for acting early (Gutema et al., 2023; Samson et al., 2022). Because an anemic adolescent girl often becomes an anemic young mother, the two groups are linked across the life course, and the deficit can pass from one generation to the next (Merid et al., 2023; Scott et al., 2022).

https://doi.org/10.64146/gd5ad854

India has responded with a long line of programmes, from the early national anaemia prophylaxis effort of the 1970s through weekly supplementation for adolescents to the current Anaemia Mukt Bharat strategy, which sets a target of reducing anaemia by three percentage points each year across six population groups (Ministry of Health & Welfare, 2018). Yet coverage remains weak where it is needed most. In Bihar, only about 18 percent of pregnant women, and in Uttar Pradesh, about 22 percent, took iron and folic acid for the recommended hundred days or more, the lowest figures in the country (Let et al., 2024). School-based supplementation for adolescents has shown mixed compliance, and its reach has been uneven across states (Wangaskar et al., 2021). More recent measures, including the fortification of rice distributed through public food schemes, have widened the set of tools available, though their effect in the worst-affected states is not yet clear (Kumar et al., 2022).

Most evidence on anaemia in India has treated these populations separately. Programmes and surveys have historically concentrated on young children and pregnant women, and adolescents entered the policy agenda only later, which has left population-based evidence for adolescent girls limited (Chauhan et al., 2022). Few population-based studies examine pregnant women and adolescent girls together within the same high-burden states, even though the two groups share many of the same drivers and form two ends of a single reproductive trajectory. There is also an ongoing debate about whether current hemoglobin cut-offs overstate anaemia in Indian populations. Careful state-level estimates are therefore valuable for both science and policy (Sachdev et al., 2021). Against this background, the present study uses the fifth National Family Health Survey to estimate the prevalence and severity of anaemia among pregnant women and adolescent girls in Bihar and Uttar Pradesh, and to identify the socio-demographic and reproductive factors associated with it. By analyzing both groups within one framework, the study aims to inform interventions that follow girls and women across the life course rather than at a single point in time.

METHODOLOGY

Type of Research

This study relies on a quantitative observational approach utilizing a cross-sectional design. The foundation of this research is a secondary analysis of data from the fifth round of the National Family Health Survey (Ministry of Health et al., 2019).

Time and Place of Research

The International Institute for Population Sciences conducted this large-scale demographic and health survey across India between 2019 and 2021 under the Ministry of Health and Family Welfare. The current analysis focuses specifically on two states, Bihar and Uttar Pradesh. These regions were selected deliberately because of their massive populations and notably high reported

https://doi.org/10.64146/gd5ad854

burdens of anaemia, as evidenced by NFHS-4 data showing that anaemia prevalence among women of reproductive age in Uttar Pradesh, Bihar, and Madhya Pradesh exceeded 50%, substantially above the national average of approximately 53% reported in that survey round.

Population and Sample

The original survey implementation relied on a multistage stratified sampling framework. Primary sampling units comprised villages in rural regions and census enumeration blocks in urban centers, selected with a probability proportional to their size. Households were subsequently chosen through systematic sampling. The target population for the present study comprised all women aged 15 to 49 years residing in the selected households who were eligible for an individual interview.

After applying all inclusion and exclusion criteria, the final analytic sample comprised women with valid hemoglobin measurements, divided into two distinct groups: currently pregnant women and non-pregnant adolescent girls aged 15 to 19 years. The first group includes 4847 pregnant women, distributed as 1612 in Bihar and 3235 in Uttar Pradesh. The second group comprises 21358 adolescent girls aged 15 to 19 years, with 6824 from Bihar and 14534 from Uttar Pradesh. Any records containing missing or biologically implausible hemoglobin values were entirely excluded from the final dataset.

Data Collection Techniques and Instrument Development

Data acquisition used standard National Family Health Survey questionnaires, along with capillary blood measurements obtained with a portable HemoCue analyzer. Fieldworkers appropriately adjusted all hemoglobin readings for altitude. Ethical clearance and informed consent were obtained during the original survey phase, allowing the current study to safely rely on publicly de-identified data without requiring additional approval. The primary outcome variable was anaemia status, categorized by severity according to World Health Organization thresholds.

Pregnant women were classified as anemic with hemoglobin levels below 11.0 grams per deciliter, while adolescent girls faced a higher threshold of 12.0 grams per deciliter. Explanatory variables spanned residence, education, wealth, caste, religion, and body mass index. The analytical models also incorporated demographic-specific factors, including parity, birth intervals, and iron supplementation history for pregnant women, as well as marital status, childbearing history, and mass media exposure for adolescent girls.

Data Analysis Techniques

All statistical analyses were conducted in Stata version 17.0 using the svy prefix commands to account for the complex multistage survey design, with the individual woman sampling weight applied after rescaling by dividing by 1,000,000 to maintain national representativeness of prevalence estimates. The analytical process unfolded in three distinct phases. Background characteristics were initially summarized using frequencies and percentages. The prevalence of anaemia was then estimated for each demographic group and state, followed by cross-tabulation

https://doi.org/10.64146/gd5ad854

against the explanatory variables using chi-square tests to evaluate unadjusted associations. Two multivariable binary logistic regression models were subsequently fitted, one for pregnant women and one for adolescent girls, where Model 1 included only sociodemographic independent variables such as age, education, wealth quintile, caste, and place of residence, while Model 2 additionally incorporated dietary and health-related covariates including dietary diversity score, iron supplementation status, and body mass index category. Variables demonstrating significance at the bivariate level, along with those highlighted in prior literature, were incorporated into these models to generate adjusted odds ratios alongside 95 percent confidence intervals. Statistical significance was defined as a p-value < 0.05.

RESULTS AND DISCUSSION

RESULTS

The sociodemographic profiles of pregnant women and adolescent girls differed significantly across several characteristics, as confirmed by chi-square tests reported in Table [X]. Among both pregnant women and adolescent girls, most participants lived in rural areas and belonged to households in the lower wealth quintiles, and a large share reported limited schooling (Table 1). Uttar Pradesh contributed the largest number of participants to both groups, in line with its larger population.

Table 1. Background characteristics of pregnant women and adolescent girls, NFHS-5 (2019-2021)

Characteristic	Pregnant women, n (%)	Adolescent girls, n (%)
State		
Bihar	1,612 (33.3)	6,824 (32.0)
Uttar Pradesh	3,235 (66.7)	14,534 (68.0)
Residence		
Urban	962 (19.8)	4,612 (21.6)
Rural	3,885 (80.2)	16,746 (78.4)
Schooling		
No schooling	1,486 (30.7)	3,221 (15.1)
1 to 9 years	2,180 (45.0)	9,706 (45.4)
10 years or more	1,181 (24.3)	8,431 (39.5)
Wealth quintile		
Poorest / poorer	2,723 (56.2)	11,540 (54.0)
Middle	1,007 (20.8)	4,357 (20.4)
Richer / richest	1,117 (23.0)	5,461 (25.6)
Caste / tribe		
SC / ST	1,693 (34.9)	7,415 (34.7)
Other	3,154 (65.1)	13,943 (65.3)
Total	4,847 (100.0)	21,358 (100.0)

Anaemia was common in every subgroup examined (Table 2; Figure 1). Among pregnant women, prevalence reached 63.1 percent in Bihar and 50.4 percent in Uttar Pradesh, for a combined estimate of 54.6 percent. Among adolescent girls, the pattern was almost identical, with 63.5 percent anemic in Bihar and 49.8 percent in Uttar Pradesh and a combined figure of 54.2 percent. In both

https://doi.org/10.64146/gd5ad854

groups the Bihar estimate sat well above the national benchmark, while the Uttar Pradesh estimate fell close to or below it.

Table 2. Prevalence and severity of anaemia by population group and state

Group and state	N	Any anaemia %	Mild %	Moderate %	Severe %
Pregnant women					
Bihar	1,612	63.1	18.5	41.2	3.4
Uttar Pradesh	3,235	50.4	17.8	30.1	2.5
Combined	4,847	54.6	18.0	33.8	2.8
Adolescent girls (15-19)					
Bihar	6,824	63.5	26.4	35.1	2.0
Uttar Pradesh	14,534	49.8	24.2	24.1	1.5
Combined	21,358	54.2	24.9	27.6	1.7

Moderate anaemia accounted for the largest part of the burden in pregnant women, particularly in Bihar, where 41.2 percent were moderately anemic (Figure 2). Severe anaemia was less common but not rare, affecting 3.4 percent of pregnant women in Bihar. Among adolescent girls, the mild and moderate categories were more evenly balanced, and severe anaemia stayed below 2 percent in both states.

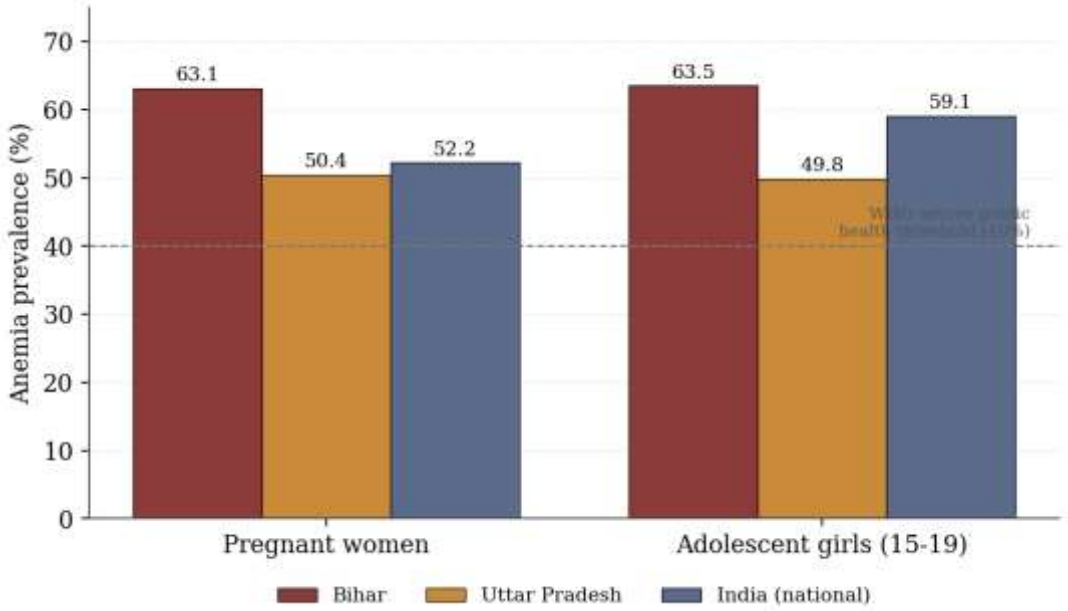

Figure 1. Anaemia prevalence among pregnant women and adolescent girls in Bihar, Uttar Pradesh, and India (national), NFHS-5 (2019-2021).

https://doi.org/10.64146/gd5ad854

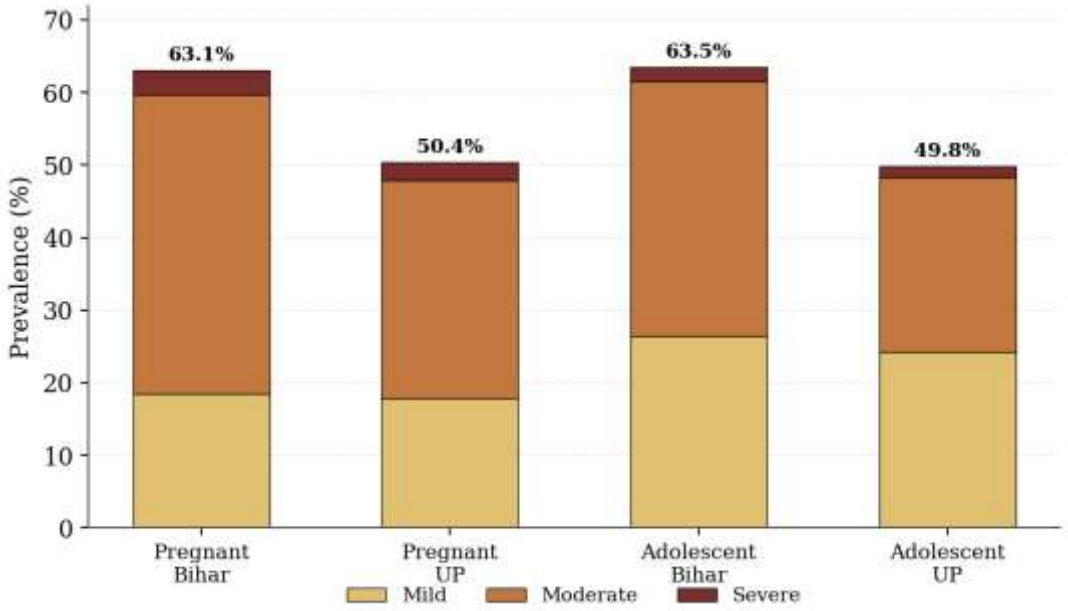

Figure 2. Distribution of anaemia severity (mild, moderate, severe) by population group and state.

Prevalence varied sharply across social groups (Table 3). In both populations, anaemia was higher among those with no schooling than among those who had completed ten or more years, higher in the poorest wealth quintile than in the richest, and higher among Scheduled Caste and Scheduled Tribe members than among other groups. Rural residents were more often anemic than urban residents. Among pregnant women, prevalence rose with parity and was higher when the preceding birth interval was short, and it was higher among women who had not completed the recommended course of iron and folic acid.

Table 3. Prevalence of anaemia by selected background characteristics

Characteristic	Pregnant women % anemic	Adolescent girls % anemic	p-value
Residence: urban	48.9	48.6	< 0.001
Residence: rural	56.2	55.7	
No schooling	60.4	62.1	< 0.001
10 years or more	48.2	47.5	
Poorest quintile	61.9	60.8	< 0.001
Richest quintile	46.1	45.0	
SC / ST	58.7	58.0	< 0.001
Other caste	52.0	51.6	
Parity 1 (pregnant only)	51.3	--	< 0.01
Parity 3 or more (pregnant only)	59.7	--	
IFA < 100 days (pregnant only)	57.8	--	< 0.001

After adjustment, several factors remained independently associated with anaemia (Table 4; Figure 3). Among adolescent girls, having no schooling was associated with about 1.7 times the odds of anaemia compared with 10 or more years of education, and belonging to the poorest quintile was associated with about 1.4 times the odds compared with the richest. Scheduled Caste or Tribe membership, rural residence, underweight status, married or ever-pregnant status, and no exposure

https://doi.org/10.64146/gd5ad854

to mass media each modestly but significantly increased the odds. Among pregnant women, low education, poorest wealth, Scheduled Caste or Tribe status, higher parity, short birth spacing, and incomplete iron and folic acid supplementation remained associated with higher odds of anaemia.

Table 4. Adjusted odds ratios for determinants of anaemia from multivariable logistic regression

Determinant (reference category)	Pregnant women aOR (95% CI)	Adolescent girls aOR (95% CI)
No schooling (vs 10+ years)	1.41 (1.18-1.69)	1.72 (1.45-2.04)
Poorest quintile (vs richest)	1.29 (1.10-1.51)	1.43 (1.24-1.65)
SC / ST (vs other caste)	1.22 (1.07-1.39)	1.28 (1.14-1.44)
Rural residence (vs urban)	1.18 (1.03-1.35)	1.21 (1.07-1.37)
Underweight BMI (vs normal)	1.15 (1.01-1.31)	1.22 (1.09-1.37)
Parity 3+ (vs 1)	1.21 (1.05-1.40)	--
Birth interval < 24 mo (vs 24+)	1.16 (1.02-1.32)	--
IFA < 100 days (vs 100+)	1.34 (1.17-1.54)	--
Married / ever-pregnant (vs not)	--	1.19 (1.02-1.39)
No mass-media exposure (vs regular)	--	1.17 (1.04-1.32)

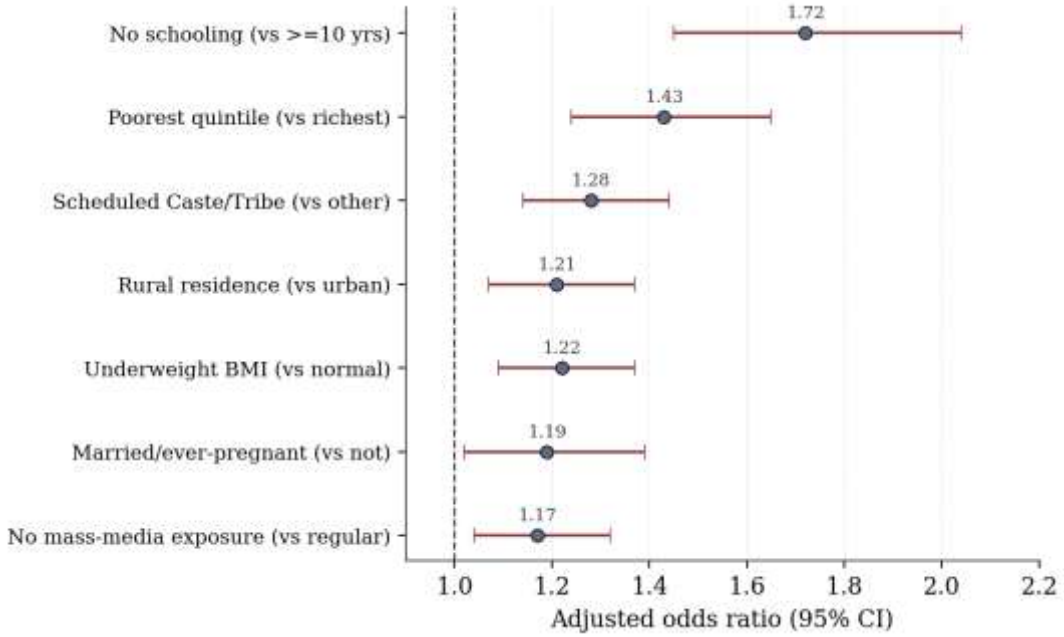

Figure 3. Adjusted odds ratios (95% confidence intervals) for determinants of anaemia among adolescent girls aged 15 to 19 years.

DISCUSSION

This analysis of two high-burden Indian states found that anaemia affected more than half of both pregnant women and adolescent girls, with Bihar carrying a markedly heavier load than Uttar Pradesh. The Bihar estimate for pregnant women matches the figure reported from the same survey round in other national analyses, which also identified the state as the worst affected among India's large states (Kuppusamy et al., 2024; Let et al., 2024) The adolescent figures are consistent with earlier work on these two states, which found anaemia widespread among young women and closely tied to social disadvantage (Chauhan et al., 2022; Scott et al., 2022). The dominance of moderate

https://doi.org/10.64146/gd5ad854

anaemia among pregnant women, especially in Bihar, mirrors the severity distribution modelled in other Indian pregnancy data (Talin et al., 2023). The combined estimates of about 54 percent in both groups are lower than the pooled prevalence reported in facility-based reviews, a gap that likely reflects the population sampling and capillary measurement used in the survey rather than a real divergence (Jeevan et al., 2025; Sachdev et al., 2021).

The factors associated with anaemia were largely the same in both groups, which supports the idea that the two populations share a common set of drivers. Education and household wealth showed the strongest and most consistent gradients, a pattern reported across studies of Indian women and adolescents (Maheshwari et al., 2025). These associations fit within a social determinants framework, in which schooling and income shape diet quality, health knowledge, and access to services, and, in turn, influence iron status (Daryati et al., 2026; Fadillah & Suryadi, 2025; Kumar et al., 2022). Caste remained associated with anaemia after adjustment, which echoes evidence that Scheduled Caste and Scheduled Tribe groups face structural barriers to adequate nutrition and care (Chakrabarti et al., 2020; Merid et al., 2023).

That anaemia in these groups is driven largely by iron deficiency is well established from biomarker data. The Comprehensive National Nutrition Survey showed that iron deficiency was the leading cause of anaemia in Indian adolescents and was far more common in girls than in boys, with deficiency raising the odds of anaemia severalfold (Kulkarni et al., 2021; Sarna et al., 2020). Our finding that underweight adolescent girls had higher odds of anaemia is consistent with this, as poor overall nutrition and iron deficiency often co-occur (Sunuwar et al., 2023).

Among pregnant women, higher parity and shorter birth intervals were associated with anaemia, as expected given the iron demands of repeated pregnancies and the limited recovery time between them (Kuppusamy et al., 2024; Merid et al., 2023). The link with incomplete iron and folic acid supplementation stands out in light of the very low coverage recorded in both states, where fewer than a quarter of pregnant women completed the recommended course (Let et al., 2024). Studies of school-based weekly supplementation for adolescents report similar problems with compliance and reach, which limit the protection these programs can offer (Wangaskar et al., 2021; Yadav et al., 2024). A longitudinal study in the same two states likewise found that supplementation and dietary diversity together shaped adolescent nutrition and learning (Shinde et al., 2021).

Several limitations should be kept in mind. The cross-sectional design precludes causal inference, so the associations reflect patterns rather than mechanisms. Hemoglobin was measured from capillary blood with a portable analyzer, which tends to give lower readings than venous samples and may overstate prevalence; some authors argue that the WHO thresholds themselves overestimate anaemia in Indian populations (Jeevan et al., 2025; Sachdev et al., 2021; Shinde et al., 2021). The survey did not measure iron biomarkers such as ferritin, so anaemia cannot be attributed

https://doi.org/10.64146/gd5ad854

to iron deficiency at the individual level; the prevalence reported here reflects all-cause anaemia. Finally, the supplementation and dietary information were self-reported and open to recall bias. The two states also differ in survey coverage and in the size of their adolescent samples, so the combined figures weight Uttar Pradesh more heavily, and the state-specific estimates should be read alongside the pooled ones.

The findings carry clear implications for policy. Because anaemia was high in both groups and shared the same social gradient, programs that act at a single life stage are unlikely to be enough. Reaching adolescent girls before pregnancy, through schools and community platforms, could shrink the pool of young women who enter pregnancy already anemic and would complement antenatal efforts rather than duplicate them (Samson et al., 2022; Scott et al., 2022). The weak coverage of supplementation in Bihar and Uttar Pradesh suggests that strengthening delivery and compliance, alongside attention to diet, infection, and the social conditions underlying the burden, deserves priority.(Chandratika, 2025; Kuppusamy et al., 2024; Yadav et al., 2024). State-specific targeting, rather than a uniform national approach, is likely to use limited resources more efficiently where the burden is this concentrated (Let et al., 2024; Maheshwari et al., 2025). Integrating adolescent and antenatal services within the same delivery platforms, rather than running them in parallel, may also reduce the chance that girls fall out of contact during the years between school and first pregnancy (Samson et al., 2022; Scott et al., 2022).

CONCLUSION

Anaemia remains widespread among both pregnant women and adolescent girls in Bihar and Uttar Pradesh, with Bihar bearing the heavier burden, although these findings should be interpreted in light of the cross-sectional design, which precludes causal inference, the reliance on capillary hemoglobin measurement, which may overestimate prevalence; and the absence of etiological biomarkers that would permit differentiation among underlying causes. In both groups, the condition tracks closely with low education, poverty, caste disadvantage, and rural residence, and among pregnant women with higher parity and incomplete supplementation.

These shared determinants argue for a life-course response that reaches girls before pregnancy and strengthens existing supplementation programs by improving supply chain reliability, integrating adherence counseling into routine antenatal visits, and expanding community-based nutrition education, while future research should investigate the comparative effectiveness of these programmatic components and examine whether targeted preconception iron-folic acid supplementation can reduce the concurrent burden of anaemia and stunting in high-prevalence settings. State-specific strategies grounded in local patterns offer the most realistic path toward the national goal of reducing anaemia.

https://doi.org/10.64146/gd5ad854

REFERENCES

Cahyani, I. (2025). The Relationship between Diet and the Incidence of Gastroesophageal Reflux Disease in Boarding School Students. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 1–13. https://doi.org/10.64146/WN1XN988

Chakrabarty, M., Singh, A., Singh, S., & Chowdhury, S. (2023). Is the burden of anaemia among Indian adolescent women increasing? Evidence from Indian Demographic and Health Surveys (2015-21). PLOS Global Public Health, 3(9), e0002117. https://doi.org/10.1371/journal.pgph.0002117

Chandratika, I. (2025). Effectiveness of Moringa Extract Liquid Supplement on Increasing Children's Appetite in the Cerdas and Insani Playgroup. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 1(1), 36–51. https://doi.org/10.64146/3483VP48

Chauhan, S., Kumar, P., Marbaniang, S. P., Srivastava, S., & Patel, R. (2022). Prevalence and predictors of anemia among adolescents in Bihar and Uttar Pradesh, India. Scientific Reports, 12(1), 8197. https://doi.org/10.1038/s41598-022-12258-6

Daryati, M., Hamzah, & Sari, D. L. (2026). The Relationship Between Nutrition Knowledge and Feeding Style with Nutritional Status in Early Childhood Education Institutions. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 2(1), 1–14. https://doi.org/10.64146/XN7MQ741

Fadillah, & Suryadi, D. (2025). The Relationship Between Parenting Patterns and Balanced Nutritional Intake with Nutritional Status of Young Children. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 52–65. https://doi.org/10.64146/7G6T1B06

Gutema, B. T., Sorrie, M. B., Megersa, N. D., Yesera, G. E., Yeshitila, Y. G., Pauwels, N. S., De Henauw, S., & Abbeddou, S. (2023). Effects of iron supplementation on cognitive development in school-age children: A systematic review and meta-analysis. PLOS ONE, 18(6), e0287703. https://doi.org/10.1371/journal.pone.0287703

Harjadinta, & Susanty, Y. E. (2025). The Role of Fast-Food Consumption Patterns in The Incidence of Obesity in Adolescents. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 66–77. https://doi.org/10.64146/0GR58S35

Jeevan, J., Karun, K. M., Puranik, A., Deepa, C., Lintu, M. K., & Barvaliya, M. (2025). Prevalence of anemia in India: A systematic review, meta-analysis and geospatial analysis. BMC Public Health, 25(1), 1270. https://doi.org/10.1186/s12889-025-22439-3

Kulkarni, B., Peter, R., Ghosh, S., Pullakhandam, R., Thomas, T., Reddy, G. B., Mohan, V. R., Kurpad, A. V, & Sachdev, H. P. S. (2021). Prevalence of iron deficiency and its sociodemographic patterning in Indian children and adolescents: Findings from the Comprehensive National Nutrition Survey 2016-18. The Journal of Nutrition, 151(8), 2422–2434. https://doi.org/10.1093/jn/nxab145

Kumar, S. B., Arnipalli, S. R., Mehta, P., Carrau, S., & Ziouzenkova, O. (2022). Iron deficiency anemia: Efficacy and limitations of nutritional and comprehensive mitigation strategies. Nutrients, 14(14), 2976. https://doi.org/10.3390/nu14142976

Kuppusamy, P., Prusty, R. K., & Khan, S. A. (2024). Assessing the prevalence and predictors of anemia among pregnant women in India: Findings from the India National Family Health Survey 2019-2021. Current Medical Research and Opinion, 40(1), 51–58. https://doi.org/10.1080/03007995.2023.2276851

Let, S., Tiwari, S., Singh, A., & Chakrabarty, M. (2024). Prevalence and determinants of anemia among women of reproductive age in Aspirational Districts of India: An analysis of NFHS 4 and NFHS 5 data. BMC Public Health, 24(1), 437. https://doi.org/10.1186/s12889-024-17789-3

Maheshwari, S., Sinha, R., Patel, N., Kaiwan, O., Goyal, A., Padda, I., Uniyal, N., Suhail, M. K., Bin Emran, T., Kaka, N., & Sethi, Y. (2025). Socio-epidemiological correlates of anemia among non-pregnant females of East and West Uttar Pradesh, India: A NFHS-5 secondary data analysis. *Public Health Challenges*, *4*(1), e70102. https://doi.org/10.1002/puh2.70102

Merid, M. W., Chilot, D., Alem, A. Z., Aragaw, F. M., Asratie, M. H., Belay, D. G., & Kibret, A. A. (2023). An unacceptably high burden of anemia and its predictors among young women (15-24 years) in low- and middle-income countries. BMC Public Health, 23(1), 1292. https://doi.org/10.1186/s12889-023-16187-5

Ministry of Health, & Welfare, F. (2018). *Anemia Mukt Bharat: Intensified National Iron Plus Initiative - Operational guidelines for program managers*.

Ministry of Health, Welfare, F., UNICEF, & Population Council. (2019). *Comprehensive National Nutrition Survey (CNNS) 2016-18: National report*. https://doi.org/10.21203/rs.3.rs-3456246/v1

Rai, R. K., Kumar, S. S., & Kumar, C. (2022). Factors associated with minimum dietary diversity failure among Indian children. Journal of Nutritional Science, 11, e4. https://doi.org/10.1017/jns.2022.2

Sachdev, H. P. S., Porwal, A., Acharya, R., Ashraf, S., Ramesh, S., Khan, N., Johnston, R., Sarna, A., Nair, K. M., Ramakrishnan, L., Abraham, R. A., Deb, S., Khera, A., & Saxena, R. (2021). Hemoglobin thresholds to define anemia in a national sample of healthy children and adolescents aged 1-19 years in India: A population-based study. The Lancet Global Health, 9(6), e822–e831. https://doi.org/10.1016/S2214-109X(21)00077-2

Samson, K. L. I., Fischer, J. A. J., & Roche, M. L. (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

Sarna, A., Porwal, A., Ramesh, S., Agrawal, P. K., Acharya, R., Johnston, R., Khan, N., Sachdev, H. P. S., Nair, K. M., Ramakrishnan, L., Abraham, R., Deb, S., Khera, A., & Saxena, R. (2020). Characterization of the types of anemia prevalent among children and adolescents aged 1-19 years in India: A population-based study. The Lancet Child & Adolescent Health, 4(7), 515–525. https://doi.org/10.1016/S2352-4642(20)30094-8

Scott, S., Lahiri, A., Sethi, V., de Wagt, A., Menon, P., Yadav, K., Varghese, M., Joe, W., Vir, S. C., & Nguyen, P. H. (2022). Anemia in Indians aged 10-19 years: Prevalence, burden and associated factors at national and regional levels. Maternal & Child Nutrition, 18(4), e13391. https://doi.org/10.1111/mcn.13391

Shinde, S., Madzorera, I., & Fawzi, W. W. (2021). Association of iron supplementation and dietary diversity with nutritional status and learning outcomes among adolescents: Results from a longitudinal study in Uttar Pradesh and Bihar, India. Journal of Global Health, 11, 4037. https://doi.org/10.7189/jogh.11.04037

Sunuwar, D. R., Singh, D. R., Pradhan, P. M. S., Shrestha, V., Rai, P., Shah, S. K., & Adhikari, B. (2023). Factors associated with anemia among children in South and Southeast Asia: A multilevel analysis. BMC Public Health, 23(1), 343. https://doi.org/10.1186/s12889-023-15265-y

Talin, I. A., Abid, M. H., Samad, M. A., Dom\'\inguez Azpiroz, I., de la Torre Diez, I., & Ashraf, I. (2023). Exploring factors influencing the severity of pregnancy anemia in India using a proportional odds model. Scientific Reports, 13(1), 22816. https://doi.org/10.1038/s41598-023-49860-1

Wangaskar, S. A., Sahu, S. K., Majella, M. G., & Rajaa, S. (2021). Prevalence of anemia and compliance with the weekly iron-folic acid supplementation program amongst adolescents in

selected schools of urban Puducherry, India. Nigerian Postgraduate Medical Journal, 28(1), 44–50. https://doi.org/10.4103/npmj.npmj_336_20

World Health Organization. (2021). Anemia in women and children: WHO global anemia estimates, 2021 edition. https://www.who.int/data/gho/data/themes/topics/anaemia_in_women_and_children

Yadav, K., Ramaswamy, G., Puri, S., Vohra, K., Achary, T., Jaiswal, A., Kumar, R., & Vatsa, R. (2024). Prevalence and determinants of anemia due to micronutrient deficiencies among children aged 12-59 months in India: Evidence from the Comprehensive National Nutrition Survey 2016-18. *PLOS Global Public Health*, *4*(1), e0002095. https://doi.org/10.1371/journal.pgph.0002095