

Anaemia among Women of Reproductive Age (15-49 years) in the EAG States and Assam, India: Inter-District Variation and Socio-Demographic Correlates

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Background

Anaemia remains a persistent global public health concern, affecting a substantial proportion of women of reproductive age. According to the World Health Organization (WHO), the estimated prevalence of anaemia among women aged 15–49 years increased from 27.6% in 2012 to 30.7% in 2023, indicating insufficient progress in reducing the global burden. The African and South-East Asia Regions are among the most affected, and current trends and future projections suggest that global, regional, and national efforts remain insufficient to achieve the 2030 global anaemia target of a 50% reduction among women of reproductive age (WHO, 2025).

Anaemia is a condition characterised by a lower-than-normal number of red blood cells, which reduces the oxygen supply to the body's tissues and organs. It may cause symptoms such as fatigue, lethargy, shortness of breath, and dizziness. Beyond its effects on individual health and well-being, anaemia can reduce productivity and contribute to socioeconomic losses. Women of reproductive age are particularly vulnerable because of menstrual blood loss and the increased nutritional demands associated with pregnancy. Maternal anaemia is associated with obstetric complications, maternal and perinatal mortality, miscarriage, and low birth weight, while children affected by anaemia may experience impaired cognitive and motor development (WHO, 2023; Hess et al., 2023).

The causes of anaemia vary across populations and settings, with iron deficiency generally recognised as a major contributor. However, the proportion of anaemia cases attributable to iron deficiency varies considerably, ranging from approximately 10% to more than 60%, depending on the population and context (Petty et al., 2016; Wirth et al., 2017). This variation highlights the multifactorial nature of anaemia and the importance of considering its diverse underlying causes when developing prevention and control strategies. In this context, India presents a particularly important setting for examining the burden of anaemia, given its high prevalence among women and children. According to the National Family Health Survey-5 (NFHS-5),

conducted during 2019–2021, 57.0% of women aged 15–49 years were anaemic, compared with 53.1% in NFHS-4 (2015–2016). This increase highlights the continuing challenge of addressing anaemia and suggests that progress in improving women's nutritional and health status has been insufficient. The high prevalence also underscores the need to examine variations across population groups and geographical areas, as national-level estimates may conceal important subnational disparities.

Within India, the eight Empowered Action Group (EAG) states—Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh, and Uttarakhand—constitute an important context for investigating health inequalities. These states have historically received policy attention because of their demographic and socioeconomic challenges and the need to improve reproductive, maternal, and child health outcomes. Variations in poverty, women's educational attainment, dietary practices, access to healthcare, and other socioeconomic conditions may contribute to differences in anaemia prevalence both within and across these states. Consequently, examining anaemia in the EAG states can provide insights into its geographical distribution and associated socioeconomic inequalities among women of reproductive age. Although Assam is not one of the original eight EAG states, it has been included in the present analysis to facilitate comparative assessment of anaemia patterns across states facing similar socioeconomic and public health challenges.

Against this background, the present study examines the prevalence of anaemia, inter-district variation, and associated sociodemographic correlates among women aged 15–49 years across the eight EAG states and Assam.

Data Source

This study utilises secondary unit-level data from the fifth round of the National Family Health Survey (NFHS-5), conducted during 2019–2021, a nationally representative cross-sectional survey conducted under the aegis of the Ministry of Health and Family Welfare (MoHFW), Government of India, with the International Institute for Population Sciences (IIPS), Mumbai, serving as the nodal agency. The analytical sample is restricted to women of reproductive age (15–49 years) residing across the Empowered Action Group (EAG) states (Bihar, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Rajasthan, and Uttarakhand) and Assam.

Statistical Methodology

The statistical strategy is executed through a sequential three-tiered analytical approach. First, to capture macro-level geographical heterogeneity and intra-state inequalities, district-level aggregation is conducted by calculating specific statistical measures of central tendency and dispersion, including the mean prevalence, absolute range, standard deviation (SD), coefficient of variation (CV), and interquartile range (IQR) for each state. Second, a descriptive bivariate framework is applied to compute the unadjusted percentage prevalence of Anaemia across distinct social, economic, and demographic strata. Third, a multivariate binary logistic regression analysis is conducted to estimate Adjusted Odds Ratios (AOR) and 95% Confidence Intervals (CI), thereby isolating the independent structural and demographic predictors of Anaemia while simultaneously controlling for overlapping confounding covariates.

An Adjusted Odds Ratio (AOR) greater than one denotes a higher likelihood of the outcome occurring within the investigated category relative to the reference group. Statistical significance was assessed at the 5% level ($p < 0.05$).

The general form of the logistic regression model can be expressed as:

$$\log\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k$$

where P represents the probability of a Women being Anaemic, β_0 is the intercept, and $X_1, \dots, X_k$ represent the selected socioeconomic, demographic, maternal and household characteristics.

Variable Framework

The primary outcome (dependent) variable in this study is the Anaemia status of women aged 15–49 years and categorised as a dichotomous variable (coded as 1 if Anaemic [mild, moderate, or severe combined] and 0 if non-Anaemic).

The predictor (independent) variables for analysis are operationalized through specific categorical coding structures as follows:

- **Social Group:** Coded as a multi-categorical caste classification encompassing Scheduled Caste (SC), Scheduled Tribe (ST), and OBC/Others.
- **Religion:** Categorized as a multi-categorical variable consisting of Hindu, Muslim, and Christian & Others.
- **Place of Residence:** Coded as a dichotomous variable consisting of Urban and Rural.
- **Educational Level of Women:** Structured as a multi-categorical variable encompassing No Education, Primary, Secondary and Higher.
- **Exposure to Media:** Classified as a dichotomous variable consisting of No Exposure and Any Exposure.
- **Work Status of Women:** Divided into a dichotomous variable comprising Not Working and Working.
- **Wealth Index:** Stratified by household asset ownership into a multi-categorical variable encompassing Poorest, Poorer, Middle, Richer, and Richest.
- **Age of Women:** Operationalized as a multi-categorical cohort variable consisting of 15–19 years, 20–29 years, 30–39 years, and 40–49 years.
- **Marital Status:** Classified as a multi-categorical variable structured as Never Married, Currently Married, Widowed, and Divorced/Separated/Deserted.
- **Geographic Region:** Operationalized as a multi-categorical variable capturing the administrative boundaries of the EAG States (Uttarakhand, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh) and Assam.

Analysis

Inter-District Variation in Anaemia Prevalence across EAG States and Assam

Substantial inter-district variation observed in anaemia prevalence among women aged 15–49 years across the EAG states (Table 1 & Figure 1). The mean district-level prevalence of anaemia among women aged 15–49 years was highest in Jharkhand (66.3%), followed by Assam (65.7%), Bihar (64.7%), Odisha (64.3%) and Chhattisgarh (63.0%). These states therefore exhibited a comparatively high burden of anaemia. In contrast, the mean prevalence was lower in Rajasthan (55.4%), Madhya Pradesh (55.2%), Uttar Pradesh (50.4%) and Uttarakhand (40.2%), with Uttarakhand recording the lowest mean among the states examined.

The range of district-level prevalence demonstrates substantial geographical variation within states. Chhattisgarh had the widest range (36.1 percentage points), followed by Uttarakhand (35.4), Madhya Pradesh and Uttar Pradesh (31.4 each), and Assam (29.5). Odisha had a range of 26.9 percentage points, with district-level prevalence varying from 48.9% to 75.8%. Bihar had the narrowest range (24.6 percentage points), closely followed by Jharkhand (23.7 percentage points).

The standard deviation and coefficient of variation further indicate differences in the extent of inter-district heterogeneity. Uttarakhand recorded the highest SD (9.7) and CV (24.2%), indicating particularly high relative variation across its districts despite having the lowest mean prevalence. Chhattisgarh and Uttar Pradesh also showed relatively high relative variability (CV = 14.1% each). In comparison, Odisha had a relatively low CV of 9.2%, suggesting that although its overall anaemia burden was high, district-level prevalence was comparatively more consistent than in several other EAG states.

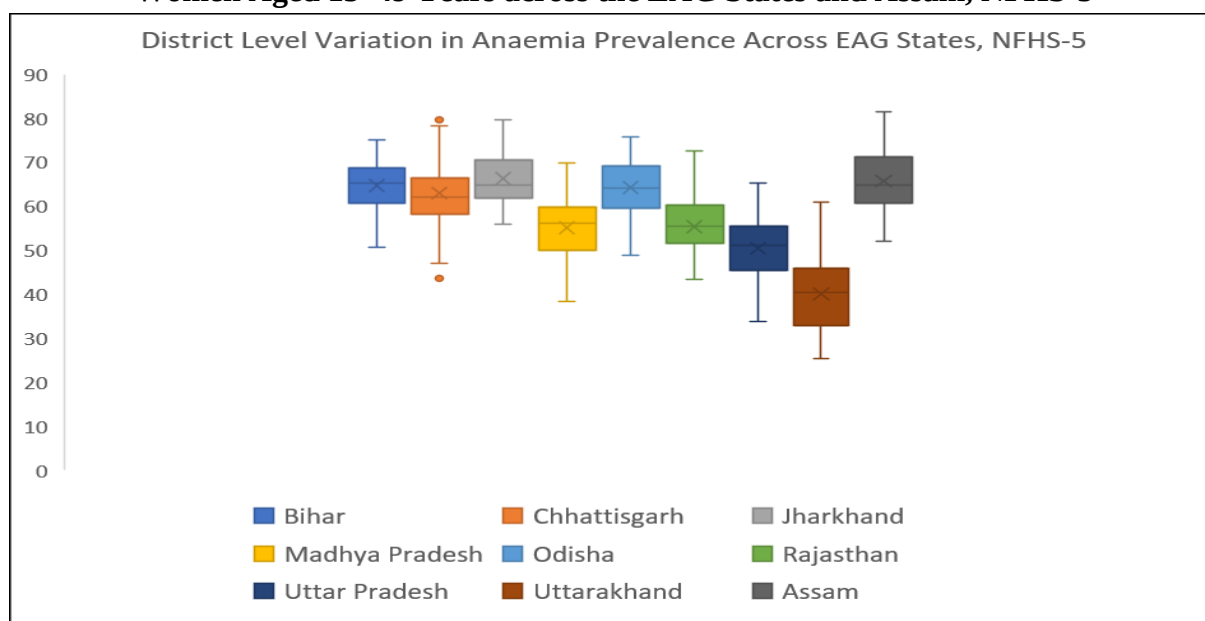
The IQR ranged from 7.4 percentage points in Bihar to 10.4 percentage points in Uttarakhand, further demonstrating differences in the concentration of district-level prevalence around the central distribution.

Table 1. Descriptive Statistics of District-Level Anaemia Prevalence among Women Aged 15–49 Years across the EAG States and Assam, NFHS-5

State/Descriptive Statistics	Mean	Median	Minimum	Maximum	Range	SD	Q1	Q3	IQR	CV (%)
Bihar	64.7	65.2	50.6	75.2	24.6	5.7	61.0	68.3	7.4	8.9
Chhattisgarh	63.0	62.2	43.6	79.7	36.1	8.9	58.4	66.4	8.0	14.1
Jharkhand	66.3	64.8	56.0	79.7	23.7	6.3	62.2	70.3	8.2	9.5
Madhya Pradesh	55.2	56.2	38.5	69.9	31.4	6.8	50.2	59.7	9.6	12.2
Odisha	64.3	64.1	48.9	75.8	26.9	5.9	60.3	68.9	8.6	9.2
Rajasthan	55.4	55.4	43.3	72.6	29.3	6.9	51.7	60.1	8.4	12.4
Uttar Pradesh	50.4	51.2	33.8	65.2	31.4	7.1	45.6	55.4	9.7	14.1

Uttarakhand	40.2	40.5	25.5	60.9	35.4	9.7	33.4	43.8	10.4	24.2
Assam	65.7	64.9	52.0	81.5	29.5	6.7	61.0	70.8	9.8	10.2

Figure 1. Box-and-Whisker Plot Showing District-Level Variation in Anaemia Prevalence among Women Aged 15–49 Years across the EAG States and Assam, NFHS-5



Anaemia Prevalence among Women Aged 15–49 Years by Background Characteristics

Table 2 presents the bivariate analysis (cross-tabulation) of Anaemia prevalence (%) among women aged 15–49 years across the Empowered Action Group (EAG) states and Assam, broken down by key socio-economic and demographic background characteristics. The overall pooled prevalence of Anaemia across these regions stands at 56.7%.

A striking disparity is observed among social strata. Women belonging to the Scheduled Tribe (ST) category experience the highest prevalence of Anaemia at 66.7%, which is significantly higher than Scheduled Castes (SC: 56.8%) and OBC/Others (55.1%). Anaemia burden varies noticeably across religious affiliations. The highest prevalence is observed among Christian & Others at 65.2%, followed by Hindus at 57.0%. Muslim women present the lowest prevalence at 54.0%. Rural women experience a higher burden of Anaemia (57.4%) compared to their urban counterparts (54.3%). An inverse relationship is observed between educational attainment and Anaemia. Prevalence drops from 57.9% among women with no education down to 51.6% among those with higher education. Economic status shows a strong, linear protective gradient. Anaemia prevalence monotonically declines from 61.2% in the poorest wealth quintile to 50.7% in the richest wealth quintile, highlighting wealth as a powerful structural buffer. Women with regular media exposure show a lower prevalence of Anaemia (55.8%) compared to those with no media exposure (58.6%), signalling the potential impact of health literacy channels. Working women have a slightly lower prevalence of Anaemia (55.5%) than non-working women (56.8%). The youngest cohort (ages 15–19) exhibits the highest

vulnerability with an Anaemia prevalence of 59.0%. The burden gradually eases in older age groups, stabilizing around 55.3% for women aged 40–49. Vulnerability peaks among widowed women at 58.9%, followed by divorced/separated/deserted women at 57.7% and never-married women at 57.2%. Currently married women demonstrate the lowest descriptive prevalence at 56.5%. Assam (65.9%), Jharkhand (65.3%), Odisha (64.3%), and Bihar (63.5%) emerge as severe public health hot spots, with roughly two-thirds of their reproductive-age female population suffering from Anaemia. Uttarakhand reports the lowest prevalence by a wide margin at 42.6%, followed by Uttar Pradesh at 50.4%.

Table 2: Anaemia Prevalence among Women (15-49 years) across the EAG States and Assam by Background Characteristics, NFHS-5

Background Characteristics	Anaemia
Social Group	
SC	56.8
ST	66.7
OBC/Others	55.1
Religion	
Hindu	57.0
Muslim	54.0
Christian & Others	65.2
Place of Residence	
Urban	54.3
Rural	57.4
Educational Level	
No education	57.9
primary	57.3
secondary	57.3
higher	51.6
Exposure to Media	
No Exposure	58.6
Any Exposure	55.8
Work Status of Women	
Not Working	56.8
Working	55.5
Wealth Index	
poorest	61.2
poorer	57.3
middle	56.1
richer	54.0
richest	50.7

Age of Women	
15-19	59.0
20-29	57.2
30-39	55.4
40-49	55.3
Marital Status	
Never Married	57.2
Currently Married	56.5
Widowed	58.9
Divorced/separated/deserted	57.7
EAG States	
Uttarakhand	42.6
Rajasthan	54.4
Uttar Pradesh	50.4
Bihar	63.5
Jharkhand	65.3
Odisha	64.3
Chhattisgarh	60.8
Madhya Pradesh	54.7
Assam	65.9
Total	56.7

Factors Associated with Anaemia: Multivariable Binary Logistic Regression Results

The multivariate binary logistic regression analysis identified several socioeconomic, demographic, and geographic factors as statistically significant correlates of anaemia among women aged 15–49 years across the study regions (Table 3). Compared to the Scheduled Caste (SC) reference group, women belonging to Scheduled Tribes (ST) exhibit 35% higher odds of being Anaemic (AOR = 1.35; 95% CI: 1.31–1.38). Conversely, women from Other Backward Classes (OBC) and other categories show a marginal but significant reduction in risk (AOR = 0.96; 95% CI: 0.95–0.98). Religious affiliation also influences vulnerability; Muslim women have 9% lower odds of Anaemia relative to Hindu women (AOR = 0.91; 95% CI: 0.89–0.93) whereas no statistically significant difference is observed for Christian and other religious minorities. Interestingly, after adjusting for covariates, the place of residence (urban vs. rural) does not show a statistically significant relationship with Anaemia risk.

Compared to women with no formal education, achieving primary, secondary, and higher education reduces the odds of Anaemia by 4%, 8%, and 16% respectively, with higher education exhibiting the strongest protective impact (AOR = 0.84; 95% CI: 0.81–0.86). Similarly, an incremental increase in economic status yields lower Anaemia vulnerability; women in the richest wealth quintile experience a 13% reduction in risk compared to those in the poorest quintile (AOR = 0.87; 95% CI: 0.84–0.90). Additionally, any exposure to

media (AOR = 0.98) and being actively employed/working (AOR = 0.92; 95% CI: 0.88–0.95) are significantly associated with reduced odds of Anaemia.

Demographic characteristics demonstrate strong associations with nutritional outcomes. Age behaves as a protective factor relative to the youngest cohort (15–19 years), older women display significantly lower vulnerability, with both the 30–39 and 40–49 age groups experiencing a 20% decline in the odds of Anaemia (AOR = 0.80; 95% CI: 0.77–0.82). Marital status, however, exacerbates risk. Compared to never-married women, currently married women face 5% higher odds (AOR = 1.05; 95% CI: 1.02–1.08) while widowed women experience the highest vulnerability with a 16% increase in the odds of Anaemia (AOR = 1.16; 95% CI: 1.10–1.22).

Geographic location is the strongest overall predictor of Anaemia in this model. Using Uttarakhand as the reference state due to its lower baseline prevalence, all other analyzed states show dramatically elevated risks. Assam exhibits the highest vulnerability, with women facing nearly three times the odds of being Anaemic (AOR = 2.85; 95% CI: 2.72–2.98). Severe clusters of risk are also heavily pronounced in Bihar (AOR = 2.56; 95% CI: 2.46–2.67) Jharkhand (AOR = 2.50; 95% CI: 2.39–2.62), Odisha (AOR = 2.42; 95% CI: 2.31–2.53), and Chhattisgarh (AOR = 2.24; 95% CI: 2.14–2.34), Rajasthan and Uttar Pradesh also present significantly elevated odds ratios of 1.74 and 1.48, respectively.

Table 3: Multivariable Binary Logistic Regression models showing Adjusted Odds Ratios (AOR) for factors associated with Anaemia among women of reproductive age (15–49) in the EAG states and Assam, NFHS-5.

Background Characteristics	Anaemia		
	AOR	CI (95%)	
Social Group			
SC(Ref)			
ST	1.35***	1.31	1.38
OBC/Others	0.96***	0.95	0.98
Religion			
Hindu (Ref)			
Muslim	0.91***	0.89	0.93
Christian & Others	0.98	0.94	1.03
Place of Residence			
Urban (Ref)			
Rural	1.00	0.98	1.02
Educational Level			
No education (Ref)			
primary	0.96***	0.94	0.99
secondary	0.92***	0.90	0.94

higher	0.84***	0.81	0.86
Exposure to Media			
No Exposure (Ref)			
Any Exposure	0.98**	0.96	0.99
Work Status of Women			
Not Working (Ref)			
Working	0.92***	0.88	0.95
Wealth Index			
poorest (Ref)			
poorer	0.93***	0.91	0.95
middle	0.93***	0.91	0.96
richer	0.90***	0.87	0.92
richest	0.87***	0.84	0.90
Age of Women			
15-19 (Ref)			
20-29	0.92***	0.90	0.95
30-39	0.80***	0.77	0.82
40-49	0.80***	0.77	0.82
Marital Status			
Never Married (Ref)			
Currently Married	1.05***	1.02	1.08
Widowed	1.16***	1.10	1.22
Divorced/separated/deserted	1.06	0.97	1.16
EAG States			
Uttarakhand (Ref)			
Rajasthan	1.74***	1.67	1.82
Uttar Pradesh	1.48***	1.42	1.54
Bihar	2.56***	2.46	2.67
Jharkhand	2.50***	2.39	2.62
Odisha	2.42***	2.31	2.53
Chhattisgarh	2.24***	2.14	2.34
Madhya Pradesh	1.67***	1.61	1.75
Assam	2.85***	2.72	2.98

Note: CI = Confidence Interval; Ref = Reference Category; AOR = Adjusted Odds Ratio.

*** Indicates statistical significance at the 1% level ($p < 0.01$).

** Indicates statistical significance at the 5% level ($p < 0.05$).

Discussion

The findings of the present study highlight substantial socioeconomic, demographic, and geographical differences in the odds of anaemia among women aged 15–49 years across the study regions. The observed associations suggest that anaemia is not distributed uniformly across population groups and that social disadvantage and geographical context are important considerations in understanding the burden. These findings broadly align with previous research using NFHS data, which has documented socioeconomic inequalities and considerable geographical variation in anaemia among women of reproductive age in India (Balarajan et al., 2013; Barman, 2024).

Scheduled Tribe (ST) women had 35% higher adjusted odds of anaemia than Scheduled Caste (SC) women, indicating a substantial disparity between the two social groups even after controlling for other variables included in the model. This finding is consistent with previous research documenting social and socioeconomic inequalities in anaemia among women of reproductive age, including studies conducted in the Aspirational Districts and EAG states of India (Let et al., 2024; Barman, 2024). However, the observed association does not establish the specific mechanisms underlying this disparity.

Education and household wealth were inversely associated with anaemia. Compared with women with no formal education, those with primary, secondary, and higher education had 4%, 8%, and 16% lower adjusted odds of anaemia, respectively, with the largest reduction observed among women with higher education. These findings align with previous research documenting socioeconomic inequalities in anaemia among Indian women (Balarajan et al., 2013) and studies identifying education and economic circumstances as important correlates of anaemia across the EAG states (Barman, 2024).

The lower odds of anaemia among women exposed to media provide further evidence of differences associated with women's social and economic circumstances. The media association is statistically significant but small in magnitude. Media exposure may facilitate access to health information, whereas employment may be associated with greater economic independence.

Age was inversely associated with anaemia, with women aged 30–39 and 40–49 years showing 20% lower adjusted odds than adolescents aged 15–19 years. This finding is consistent with Barman (2024), who identified women aged 15–19 years as a particularly vulnerable group across the EAG states. The higher vulnerability among adolescents may be related to nutritional requirements during growth, menstrual blood loss, and dietary inadequacies, although these mechanisms were not directly assessed in the present analysis. Marital status was also associated with anaemia. Currently married women had 5% higher adjusted odds, while widowed women had 16% higher odds than never-married women. The association was strongest among widowed women, potentially reflecting differences in economic security, dietary access, and social support. However, these pathways cannot be established from the present model alone. Barman (2024) also identified women who were no longer living with a partner as a vulnerable group in the EAG states, providing related evidence that women's partnership circumstances may be associated with anaemia.

Muslim women had 9% lower adjusted odds of anaemia than Hindu women, whereas the differences among Christian women and women belonging to other religious groups were not statistically significant. This finding is consistent with previous research using nationally representative NFHS data, which reported lower anaemia prevalence among Muslim women compared with Hindu women (Balarajan et al., 2013; Gogoi & Nath, 2026).

Geographical location emerged as the strongest predictor in the model. Compared with Uttarakhand, which served as the reference state, women in Assam had 2.85 times the adjusted odds of anaemia (95% CI: 2.72–2.98). This finding highlights substantial geographical inequality in anaemia across the study regions. Barman (2024) documented marked differences in anaemia prevalence across the eight EAG states, ranging from 42.6% in Uttarakhand to 65.3% in Jharkhand, and identified geographical concentrations of high prevalence across several states and districts. Balarajan et al. (2013) also reported substantial variation in anaemia prevalence across Indian states. Together, these studies support the importance of geographical context in understanding the distribution of anaemia.

Nevertheless, the adjusted odds ratio for Assam should be interpreted as a comparison conditional on the covariates included in the model. It does not establish that geographical location itself causes anaemia. Differences in dietary patterns, socioeconomic conditions, healthcare access, and other contextual characteristics may contribute to state-level variation, but these mechanisms require further investigation. The high adjusted odds observed in Assam indicate the need for closer examination of its anaemia burden and for interventions informed by state- and district-specific evidence.

Conclusion

The study reveals a substantial burden of anaemia among women aged 15–49 years across the EAG states and Assam, alongside marked differences in mean prevalence and inter-district variability. Jharkhand, Assam, Bihar, Odisha, and Chhattisgarh recorded the highest mean district-level prevalence, whereas Uttarakhand had the lowest. The variation within states further demonstrates that state-level averages alone may not adequately capture geographical inequalities in anaemia.

The regression results identify social-group, education, household wealth, age, marital status, religious affiliation, employment, and state of residence as correlates of anaemia. Higher adjusted odds among Scheduled Tribe women, adolescents, and widowed women, together with lower odds among women with higher education and greater household wealth, highlight the unequal distribution of anaemia across population groups. The particularly high adjusted odds observed in Assam, followed by Bihar, Jharkhand, Odisha, and Chhattisgarh relative to Uttarakhand, further emphasize the importance of geographical context. Overall, the findings indicate that anaemia reduction requires an approach that combines broad-based prevention with interventions tailored to the needs of disadvantaged population groups and high-burden geographical areas. Integrating socioeconomic vulnerability and district-level variation into programme planning could improve the targeting of prevention, diagnosis, and treatment services. Further research

incorporating dietary intake, micronutrient status, infections, menstrual health, and healthcare utilization would help clarify the factors underlying the observed disparities.

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