ISSN- 0301-1216
Indian J. Prev. Soc. Med. Vol. 55, No.3, 2024

Barriers and Facilitators Contributing to Anemia among women in Northeast India: A multilevel modelling approach

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ABSTRACT

Anemia, characterized by reduced hemoglobin or red blood cell count, diminishes oxygen transport in the blood and is a significant public health issue in India's Northeast region, particularly among women, with one in two affected. This study assessed the prevalence of anemia among reproductive women in Northeast India, considering socio-economic, demographic, and dietary factors using a multilevel logistic regression model. The analysis, which examined determinants across individual, district, and state levels, found that socioeconomic status and standard of living were key determinants of anemia, with urban, well-educated women from higher socioeconomic backgrounds having lower odds of anemia. High-birthrate women and adolescents were more likely to be anemic, while non-pregnant women were more anemic than pregnant ones. Unexpectedly, not consuming vegetables reduced anemia risk, whereas abstaining from aerated beverages increased it. The multilevel analysis revealed significant variance attributable to state-level differences, indicating varied anemia prevalence across states. Efforts to address higher-order births and enhance women's economic and educational status are crucial, alongside ensuring universal access to nutrition and healthcare. Further research should explore region-specific factors to better understand the observed variations and improve health outcomes for women across Northeast India.

Keywords: Anemia, Hemoglobin, Socioeconomic

Introduction

Anemia, characterized by a deficiency in red blood cells or hemoglobin concentration, is a prevalent health issue in India, particularly among women, with approximately one in two women affected. Young Indian women, in particular, face a high burden of anemia, posing significant public health challenges due to associated iron deficiency. The Eastern region of India exhibits the highest prevalence of anemia, followed by the Northeastern and Central zones. Notably, severe anemia rates are elevated in the western and southern regions compared to the national average.[1, 2]

In India, anemia ranks as the second leading cause of maternal mortality, with women of reproductive age, especially during pregnancy, being at increased risk due to physiological and nutritional factors. A considerable proportion of pregnant women in developing nations like India suffer from anemia, which elevates the risk of adverse outcomes such as low birth weight and maternal mortality.[3]

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Submission	05.08.2024	Revision	15.08.2024	Accepted	12.09.2024	Printing	30.09.2024

Prior Publication*: Nil*; Source of Funding:* Nil; *Conflicts of Interest*: None, *Article #162/277-281

The Northeastern population, particularly women, experiences a disproportionate burden of iron deficiency anemia. Studies, including the National Family Health Survey 2016, highlight high anemia prevalence among married women in the Northeast, with pregnant women facing even higher rates compared to the national average. Notably, specific occupational groups like tea garden workers and rural farmers exhibit elevated anemia prevalence. The diverse cultural practices and autonomy of women in healthcare decision-making within Northeastern India contribute to the nuanced landscape of anemia prevalence.[4-7]

However, existing studies in the region often lack comprehensive analyses of multilevel variations and fail to address factors at individual, district, and state levels. Many studies employ fixed-effect models without considering these variations, indicating a need for more robust methodologies.[4-6,8,9]

Therefore, this study aims to assess anemia prevalence among reproductive women in Northeast India while considering multilevel variations in socioeconomic, demographic, and dietary factors. Understanding the inter-cluster variation in anemia prevalence through comprehensive analyses can inform targeted interventions to alleviate the burden of anemia in high-risk areas.

Materials and Methods

Data Source: This study utilized data from the latest National Family Health Survey (NFHS-5), conducted in India from 2019 to 2021. Focused on the northeastern region, it included 100,435 women aged 15 to 49 from (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim).

Outcome Variable: For the study, a dichotomous variable was formed: "1" for 'anemic', which included all women of reproductive age group (15-49) years and "0" for 'not-anemic' that did not have anemia.

Predictor Variable: Socio-economic, demographic, and dietary variables were examined for their association with anemia among reproductive women. The operational definition and coding of the variables under study are as follows:

[a] Socio-economic characteristics: The socio-economic characteristic of women includes:

Place of residence coded as 1=Urban, 2=Rural; Education level coded as 1=No education, 2=Primary, 3=Secondary, 4=Higher; Religion coded as 1=Hindu, 2=Muslim, 3=Christian, 4=Other; Ethnicity coded as 1=Caste, 2=Tribe, 3=No caste/tribe, 4=Don't know;

Wealth index coded as 1=Poorest, 2=Poorer, 3=Middle, 4=Richer, 5=Richest;

Children born coded as 1=No child, 2=One child, 3=Two child, 4=Three child, 5=Four or more child;

Currently Pregnant coded as 1=No or unsure, 2=Yes.

[b] Demographic characteristics: The demographic characteristic of women includes:

Age coded as 1=15-19, 2=20-24; 3=25-29; 4=30-34; 5=35-39; 6=40-44; 7=45-49;

Marital status coded as 1=Never in union, 2=Married, 3=Widowed/Divorced/Separated.

[c] Diet characteristics: Various dietary patterns include:

Milk or curd coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Pulses/beans coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Vegetables coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Fruits coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Eggs coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Fish coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Chicken or meat coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Fried foods coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally;

Aerated drink coded as 1=Never, 2=Daily, 3=Weekly, 4 = Occasionally.

Statistical analysis:

[a] Multilevel logistic regression model[11, 12, 15, 17]: The multilevel logistic regression model has been used to analyze the determinants of anemia at three levels i.e. individual, district and state.

Let π_{ijk} and (1- π_{ijk}) denote the probability of anemic and not anemic of the binary outcome to the i^{th} individual (i = 1,2,…….n) of the jth district (j =1,2,……..p) in the k^{th} state (k = 1,2,……q). For the outcome with vector of predictors X [X_1,X_2…….X_p], the logit function of multilevel mixed effect logistic model is expressed as:

$$logit(\pi ijk) = \beta 0 + \beta' \mathbf{X} + (\mathbf{d0jk} + \mathbf{s0k})$$

Where, $\beta 0$ represents the log odds of random effects associated with the individuals, $\mathbf{s0k}$ log odds of random effect associated with state and $\mathbf{d0jk}$ log odds of random effects associated with the district conditional on state when each predictor equals to zero.

[b] Model specification[13]: Four models were constructed: an initial empty model (Model I) with no explanatory variables, followed by Model II incorporating socio-economic variables, then Model III adding demographic variables, and finally, Model IV integrating dietary variables. These models aimed to evaluate associations of anemia among reproductive women in northeast India at individual, district, and state levels.

[c] Software used: Data analysis was carried by using R software version 4.3.1 [“lme4 package”].

[d] Fixed effects[13]: The result section presents fixed estimates depicting associations between outcome and predictor variables. An adjusted odds ratio (AOR) with a 95% confidence interval (CI) was calculated to identify independent factors of anemia in women.

[e] Random effects[11-13]: The random intercept model was employed to assess the clustering of participants at district and state levels. Variance Partition Coefficient (VPC) was used to quantify the random effects, indicating the proportion of total variance attributable to within-group and between-group variation. VPC at state and district levels was calculated following Snijders and Bosker's formula.

$$VPC\ at\ state\ level = \frac{\sigma_{s0}^2}{\sigma_{s0}^2 + \sigma_{d0}^2 + \frac{\pi^2}{3}}$$

$$VPC\ at\ district\ level = \frac{\sigma_{d0}^2}{\sigma_{s0}^2 + \sigma_{d0}^2 + \frac{\pi^2}{3}}$$

Where, σ_{s0}^2 = Var (s_{0k}); i.e., variance between states, σ_{d0}^2 = Var (d_{0jk}); i.e., variance between district within state and ($\frac{\pi^2}{3}$) = 3.29 refers to the standard logistic distribution, i.e., the assumed level 1 variance component.

A high VPC value in the multilevel analysis indicates that there is a high level of clustering with anemia prevalence.

Model fits were assessed using Akaike Information Criteria (AIC). AIC is a measure of the goodness of fit of a statistical model. The best fit model has the lowest AIC.[16] Multilevel logistic regression analysis partitions variation in the outcome variable, assessing differences at individual, district, and state levels to understand how factors at various levels influence the dependent variable.[14]

Results

Proportion of the study population: This study encompassed 100,435 women of reproductive age in Northeast India, revealing that 40.1% of pregnant women and 50.6% of non-pregnant women were anemic. Anemia prevalence varied across age groups, with the highest (53.3%) observed among women aged 15–19 and the lowest (48.9%) among those aged 30–34. Rural areas exhibited higher anemia rates (51.7%) compared to urban areas (43.6%). Education played a significant role, with lower anemia rates observed among women with higher education levels (43.2%) versus those with lower levels (53.9%). Hindu women had a higher prevalence of anemia (61.6%) than Christian women (39.3%). Widowed, divorced, or separated women experienced higher rates of anemia (51.1%), while those without children had lower rates (48.3%). Anemia prevalence was higher among the poorest women (55.6%) compared to the wealthier (42.1%). Women who were unsure of their ethnicity exhibited the highest anemia percentage (65.7%). Dietary patterns also influenced anemia, with higher rates observed among women who never consumed eggs (53.1%), chicken or meat (55.5%), fruits (55.5%). Women with low percentage of anemia were those who daily consume green leafy vegetables (47.1%) and milk or curd (46.1%). Interestingly, the percentage of anemia was higher in women who daily consumed fish (54.2%), fried foods (54.6%), pulses (56.7%), and aerated drinks (53.75%).

Table-1: Proportion of anaemic women in different categories (NFHS-5), North East Region (N= 100435)

Variables		Anemic (%)
Age in years	15-19	53.3
	20-24	50.7
	25-29	48.9
	30-34	48.8
	35-39	50.0
	40-44	49.4
	45-49	49.6
Place of residence	Urban	43.6
	Rural	51.7
Highest education level	No education	53.9
	Primary	52.6
	Secondary	49.8
	Higher	43.2
Religion	Hindu	61.6
	Muslim	58.1
	Christian	39.3
	Other	40.9
Ethnicity	Caste	59.5
	Tribe	41.8
	No caste/ tribe	59.4
	Don't know	65.7
Wealth index combined	Poorest	55.6
	Poorer	50.5
	Middle	47.7
	Richer	44.2
	Richest	42.1
Total number of children born	No child	48.3
	One child	52.1
	Two child	52.6
	Three child	48.6
	Four or more child	49.7
Currently Pregnant	No or unsure	50.6
	Yes	41.1
Current marital status	Never in union	48.0
	Married	50.9
	Widowed/Divorced/Separated	51.1

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Fixed effect model (measures of associations) results:

This study employed multilevel modeling analysis on anemia using data from the NFHS-5 (2019-21) dataset, revealing significant variation in anemia prevalence among women across the Northeast Region of India, as depicted in Table 2. The final model (Model IV) highlighted several factors with statistically significant associations with the prevalence of anemia among reproductive women in this region.

In Model IV, factors such as women's age, residence, wealth, education, religion, ethnicity, children born, marital status, pregnancy, consumption of milk or curd, vegetables, fruits, chicken or meat and aerated drinks were found to be significantly associated with anemia prevalence (p-value<0.05). Notably, rural residence was linked to a higher prevalence of anemia compared to urban areas (AOR=1.05, 95% CI=1.01-1.10). Women with secondary and higher education exhibited lower risks of anemia than those without education (AOR=0.92 and 0.91, respectively). Wealth also played a significant role, with middle-class, richer, and richest women having lower odds of anemia compared to the poorest women (AOR=0.93, 0.90, and 0.88, respectively).

Furthermore, women with two or more children were more likely to be affected by anemia than those without children (AOR=1.09 and 1.23). Pregnant women had significantly lower odds of anemia compared to non-pregnant women (AOR=0.71) in all the three models II, III and IV.

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Variables		Anemic (%)
Frequency takes milk or curd	Never	47.3
	Daily	46.1
	Weekly	52.1
	Occasionally	51.9
Frequency eats pulses/ beans	Never	50.2
	Daily	56.7
	Weekly	46.9
	Occasionally	43.2
Frequency eats vegetables	Never	49.3
	Daily	47.1
	Weekly	53.7
	Occasionally	55.0
Frequency eats fruits	Never	55.5
	Daily	47.0
	Weekly	50.2
	Occasionally	50.5
Frequency eats eggs	Never	53.1
	Daily	49.4
	Weekly	52.0
	Occasionally	47.1
Frequency eats fish	Never	47.0
	Daily	54.2
	Weekly	54.1
	Occasionally	43.3
Frequency eats chicken/meat	Never	55.5
	Daily	46.1
	Weekly	50.3
	Occasionally	50.0
Frequency eats fried food	Never	51.9
	Daily	54.6
	Weekly	49.2
	Occasionally	49.5
Frequency eats aerated drinks	Never	49.9
	Daily	53.7
	Weekly	48.8
	Occasionally	47.9
	Total	**50.1**

Abbreviation: NFHS, National Family Health Survey

Muslim and Christian women exhibited lower odds of anemia compared to Hindu women (AOR=0.69 and 0.89) respectively, while tribal women had lower odds compared to caste women (AOR=0.86). Regarding age, women aged 20-24 years (AOR=0.88), 25-29 years (AOR= 0.81), 30-34 years (AOR= 0.76), 35-39 years (AOR= 0.76), 40-44 years (AOR= 0.75) and 45-49 years (AOR= 0.73) were less susceptible to anemia compared to those aged 15-19 years, decreasing odds observed with increasing age. Additionally, widowed, divorced, or separated women had higher odds of anemia (AOR=1.09) compared to those never in union. After including all the variables in Model IV, dietary pattern when compared with never consumption of food, women who consume milk or curd daily and weekly (AOR= 0.93 and 0.95) and chicken or meat daily and weekly (AOR= 0.84 and 0.89) were less susceptible to anemia. However, weekly and

occasional consumption of green leafy vegetables increased the likelihood of anemia by 30% and 33%. Daily fruit consumption and occasional aerated drink consumption were associated with lower odds of anemia (AOR=0.86 and 0.95, respectively. Further, consumption of pulses or beans, eggs, fish and fried foods showed insignificant result.

Table-2: Factors associated with anemia in reproductive women of northeast India by multilevel logistic regression analysis, NFHS 2019-21.

Variables		Model I	Model II	Model III	Model IV
		Empty model	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Fixed part					
Age in years	15-19		---	Reference	Reference
	20-24		---	0.89(0.84-0.93)*	0.88(0.84-0.93)*
	25-29		---	0.81(0.76-0.86)*	0.81(0.76-0.85)*
	30-34		---	0.76(0.71-0.81)*	0.76(0.71-0.81)*
	35-39		---	0.76(0.71-0.81)*	0.76(0.71-0.81)*
	40-44		---	0.75(0.70-0.80)*	0.75(0.70-0.80)*
	45-49		---	0.73(0.68-0.79)*	0.73(0.68-0.78)*
Place of residence	Urban		Reference	Reference	Reference
	Rural		1.06(1.01-1.10)*	1.05(1.01-1.10)*	1.05(1.01-1.10)*
Highest education level	No education		Reference	Reference	Reference
	Primary		0.98(0.93-1.03)	0.97(0.92-1.01)	0.97(0.92-1.02)
	Secondary		0.95(0.91-0.99)*	0.91(0.88-0.95)*	0.92(0.88-0.96)*
	Higher		0.88(0.83-0.94)*	0.90(0.84-0.96)*	0.91(0.85-0.97)*
Religion	Hindu		Reference	Reference	Reference
	Muslim		0.71(0.67-0.76)*	0.69(0.65-0.74)*	0.69(0.65-0.74)*
	Christian		0.89(0.84-0.94)*	0.89(0.84-0.94)*	0.89(0.84-0.94)*
	Other		0.95(0.89-1.01)	0.95(0.89-1.01)	0.95(0.89-1.01)
Ethnicity	Caste		Reference	Reference	Reference
	Tribe		0.86(0.82-0.90)*	0.86(0.82-0.90)*	0.86(0.82-0.90)*
	No caste/tribe		0.99(0.94-1.05)	0.99(0.94-1.05)	0.99(0.94-1.05)
	Don't know		1.28(1.04-1.56)*	1.27(1.04-1.56)	1.27(1.03-1.55)*
Wealth index combined	Poorest		Reference	Reference	Reference
	Poorer		0.90(0.87-0.93)*	0.91(0.88-0.94)*	0.92(0.89-0.95)*
	Middle		0.89(0.86-0.93)*	0.91(0.87-0.95)*	0.93(0.89-0.97)*
	Richer		0.86(0.81-0.90)*	0.88(0.84-0.93)*	0.90(0.85-0.95)*
	Richest		0.83(0.77-0.90)*	0.85(0.79-0.92)*	0.88(0.81-0.95)*
Total no of children born	No child		Reference	Reference	Reference
	One child		0.94(0.91-0.98)*	1.02(0.96-1.09)	1.02(0.96-1.10)
	Two child		0.96(0.93-1.00)*	1.09(1.03-1.17)*	1.09(1.03-1.17)*
	Three child		0.91(0.87-0.95)*	1.05(0.98-1.13)	1.05(0.99-1.13)
	4 or more child		1.05(1.00-1.10)	1.23(1.15-1.32)*	1.23(1.14-1.32)*
Currently Pregnant	No or unsure		Reference	Reference	Reference
	Yes		0.71(0.66-0.75)*	0.71(0.66-0.76)*	0.71(0.66-0.76)*
Current marital status	Never in union			Reference	Reference
	Married			1.03 (0.96-1.09)	1.03(0.96-1.09)
	Widowed/ Divorced/ Separated			1.10 (1.01-1.20)*	1.09(1.00-1.19)*

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Variables		Model -I Empty model	Model- II AOR (95% CI)	Model-III AOR (95% CI)	Model - IV AOR (95% CI)
Frequency takes milk or curd	Never				Reference
	Daily				0.93(0.88-0.98)*
	Weekly				0.95(0.90-1.00)*
	Occasionally				0.97(0.92-1.02)
Frequency eats pulses/ beans	Never				Reference
	Daily				0.87(0.75-1.02)
	Weekly				0.91(0.78-1.06)
	Occasionally				0.93(0.80-1.09)
Frequency eats vegetables	Never				Reference
	Daily				1.27(0.98-1.64)
	Weekly				1.30(1.01-1.68)*
	Occasionally				1.33(1.03-1.72)*
Frequency eats fruits	Never				Reference
	Daily				0.86(0.75-0.98)*
	Weekly				0.88(0.78-1.01)
	Occasionally				0.90(0.80-1.02)
Frequency eats eggs	Never				Reference
	Daily				1.02(0.91-1.14)
	Weekly				0.99(0.90-1.10)
	Occasionally				0.96(0.87-1.06)
Frequency eats fish	Never				Reference
	Daily				1.03(0.91-1.16)
	Weekly				1.05(0.94-1.18)
	Occasionally				1.00(0.89-1.12)
Frequency eats chicken/meat	Never				Reference
	Daily				0.84(0.74-0.95)*
	Weekly				0.89(0.80-0.99)*
	Occasionally				0.92(0.83-1.02)
Frequency eats fried food	Never				Reference
	Daily				1.07(0.98-1.17)
	Weekly				1.06(0.97-1.16)
	Occasionally				1.08(0.99-1.18)
Frequency eats aerated drinks	Never				Reference
	Daily				0.95(0.88-1.02)
	Weekly				0.99(0.94-1.04)
	Occasionally				0.95(0.92-0.99)*

AOR, Adjusted odds ratio; CI, Confidence interval; Model I is the null model, a baseline model without any explanatory variable; Model II is adjusted for socio-economic variables; Model III is adjusted for socio-economic and demographic variables; Model IV is the final model adjusted for socio-economic, demographic and diet; *p<0.05.

Random intercept model (measures of variations) results:

Table 3 presents findings from the random intercept model, examining anemia prevalence variation at the state and district levels in northeast India. The empty model revealed non-random anemia prevalence among reproductive women across districts and states. The variance partition coefficient (VPC) indicated that the empty model attributed

9.73% and 2.77% of the total variation in anemia prevalence to states and districts, respectively, underscoring the necessity for a multilevel logistic regression model over a single-level model.

Following adjustments for socio-economic, demographic, and dietary variables, the full model showed a decrease in anemia variation attributed to state differences, while district-level variation slightly increased from Model I to Model IV. A high VPC value at the state level revealed that the variation in the prevalence of anemia was mostly attributable to differences between states. Regarding model comparison/fitness statistics, we used Akaike Information Criteria (AIC). Akaike Information Criteria (AIC) values demonstrated successive reductions across models, signifying substantial improvement in each model iteration and endorsing the goodness of fit of Model IV. Model IV, with the lowest AIC, emerged as the best-fitting model for predicting anemia likelihood among reproductive women in northeast India.

Table-3: Random effect and model fit statistics for anemia in reproductive women of northeast India by multilevel logistic regression analysis, NFHS 2019-21.

Random part	Model 1	Model 2	Model 3	Model 4
Variance Partition Coefficient (%) (VPC)				
• Level 3 (State)	9.73	8.54	8.42	8.30
• Level 2 (District)	2.77	2.47	2.49	2.51
Model fitness				
• Akaike Information Criteria (AIC)	128401.1	127953.2	127863.1	127838.0

VPC, Variance Partition Coefficient; **AIC**, Akaike Information Criteria

Discussion

A recent study utilizing NFHS-5 (2019-21) data among reproductive women in Northeast India seeks to elucidate anemia determinants at individual, district, and state levels. Findings indicate varying anemia prevalence across regions, influenced by diverse dietary habits, socio-cultural factors, and ethnic diversity among women.

A statistical approach of multilevel logistic regression was chosen due to the hierarchical data structure. A single-level logistic model would have been inappropriate as it assumes independence among all observations, while within-cluster observations tend to be more similar, indicating dependence. The NFHS-5 dataset exhibited variation at state and district levels, warranting consideration of higher-level factors.[11, 12, 15, 17]

Socio-economic factors significantly impact anemia prevalence in Northeast India. Lower income, education, and rural residence are associated with higher anemia risk due to limited access to nutritious food. Improving women's education and socio-economic status is vital for anemia control.[2, 4, 10, 18, 19] Hindu women in Northeast India face highest anemia risk; Christian women are comparatively privileged[2,19]. Pregnant women have lower anemia levels than non-pregnant women, possibly due to better access to iron supplements.[18,20] Tribal communities, particularly those unaware of their ethnicity, have a high anemia prevalence, requiring timely iron supplement delivery.[8, 19] Women who have had two or more children are more likely to be anemic, possibly due to persistent childbirth increasing the risk of iron deficiency anemia.[26] Addressing disparities, improving iron supplement access crucial for anemia control.

Age significantly influences anemia incidence. This study found higher anemia prevalence among young adolescent women, decreasing with age. Approximately 40% of Indian adolescent girls are affected by anemia.[3,25] In contrast, a previous study in northeast India suggested higher anemia prevalence among women aged 35 to 49.[6] Widowed, divorced, or separated women from northeast India also showed a negative impact on anemia prevalence, consistent with findings from a study in India's EAG states.[22]

The prevalence of anemia among women of reproductive age in Northeast India is heavily influenced by diet, particularly the consumption of iron-rich foods like pulses and green leafy vegetables.[6] Vegetarian diets are often linked to a higher risk of iron-deficiency anemia, as indicated by various studies showing lower hemoglobin levels in vegetarians compared to non-vegetarians.[21, 28, 29] However, our study surprisingly found lower rates of anemia among women who never consumed vegetables, while the intake of pulses had minimal effects. Among non-vegetarian diets, higher prevalence of anemia was observed among women who never consumed chicken or meat, whereas those consuming fish and eggs had lower rates. Daily consumption of meat, fish, and eggs was associated with a reduced risk of anemia, consistent with previous Indian research.[21] Additionally, regular consumption of milk or curd was linked to lower anemia likelihood in Northeast women.[21] However, the absence of fruit consumption increased the risk of anemia, contradicting findings from other Indian studies.[21] Surprisingly, never consuming aerated beverages was associated with a higher risk of anemia, contrary to popular belief.[23] Consumption of fried foods did not show a significant correlation with anemia prevalence, consistent with earlier investigations in Northeast India.[6] It's imperative to prioritize a balanced diet rich in various nutrient-dense foods and beverages to prevent and treat anemia in women of Northeast India, emphasizing the importance of obtaining sufficient iron from dietary sources.[23, 24]

Conclusion

A multilevel model was employed to assess anemia prevalence, capturing both fixed and random effects to enhance prediction accuracy due to the hierarchical data structure. Notably, the analysis unveiled significant between-state differences in northeast India, highlighted by a high Variance Partition Coefficient (VPC) at the state level. Urban, well-educated women with higher socioeconomic backgrounds exhibited lower odds of anemia, whereas high-birthrate women and adolescents were more susceptible. Surprisingly, non-pregnant women had higher anemia rates than pregnant women. Additionally, never consuming vegetables decreased anemia likelihood, while avoiding aerated drinks increased it. Addressing women's economic and educational disparities, reducing higher-order births, and ensuring universal access to healthcare and nutrition are crucial. Further research into region-specific factors is warranted to comprehensively address the observed variation and enhance women's health across states in the region.

Ethics

This study was a secondary analysis based on the currently existing dataset from the recent NFHS-5 survey with no identifiable information on the survey participants and did not directly involve with human participants or experimental animals. NFHS-5 obtained the consent before and during the survey. This dataset is available in the public domain for research use, therefore the ethics approval was not required in this paper.

Funding: The research received no specific grant from any funding agency in public, commercial, or not-for-profit sectors.

Conflict of Interest: The authors declare that there is no conflict of interest.

Data Access: The data can be accessed from the DHS website at https://dhsprogram.com/data/.

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References

1. Nair M, Choudhury SS, Rani A, Solomi C, Kakoty SD, Medhi R, Rao S, Mahanta P, Zahir F, Roy I, Chhabra S. The complex relationship between iron status and anemia in pregnant and postpartum women in India: Analysis of two Indian study cohorts of uncomplicated pregnancies. American Journal of Hematology. 2023 Nov; 98 (11): 1721-31.
2. Bharati P, Som S, Chakrabarty S, Bharati S, Pal M. Prevalence of anemia and its determinants among nonpregnant and pregnant women in India. Asia Pacific Journal of public health. 2008 Oct; 20 (4) : 347-59.
3. Simon NH, Akinola A, Kumar ND. Anemia prevalence and factors associated among pregnant women in India. Int J Community MedPublic Health 2021; 8: 5084-8.
4. Choudhury S, Kumar S. Gender discrimination and marginalization of women in North‐East India. Journal of Public Affairs. 2022 Nov; 22 (4):e2625.
5. Bora R, Sable C, Wolfson J, Boro K, Rao R. Prevalence of anemia in pregnant women and its effect on neonatal outcomes in Northeast India. The Journal of Maternal-Fetal & Neonatal Medicine. 2014 Jun 1; 27 (9):887-91.
6. Mog M, Neogi D, Bharadwaz MP, Panda BK, Sil A. Prevalence and factors associated with Anaemia in Married Women of Reproductive age group: Evidence from North East India. Journal of Biosocial Science. 2023 May; 55 (3) : 425-37.
7. *Phek district.* Available from: https://en.wikipedia.org/wiki/Phek_district. [Internet]
8. Vungneihchoi J, Sachdeva MP. High burden of anemia and malnutrition in two tribal populations of Northeast India. medRxiv. 2023:2023-01.
9. De M, Halder A, Podder S, Sen R, Chakrabarty S, Sengupta B, Chakraborty T, Das U, Talukder G. Anemia and hemoglobinopathies in tribal population of Eastern and North-eastern India. Hematology. 2006 Oct 1;11(5-6): 371-3.
10. Gogoi M, Prusty RK. Maternal anaemia, pregnancy complications and birth outcome: evidences from north-east India. Journal of North East India Studies. 2013 Jan;3(1):74-85.
11. Dubey P, Singh NA, Mishra RN, Mishra A. Assessment of differentials of risk factors for full antenatal care and complete immunisation coverage between rural and urban population of India-A multilevel modelling approach. NeuroQuantology. 2022; 20 (11):1933.
12. Dutta M, Bhise M, Prashad L, Chaurasia H, Debnath P. Prevalence and risk factors of anemia among children 6–59 months in India: A multilevel analysis. Clinical Epidemiology and Global Health. 2020 Sep 1; 8(3):868-78.
13. Ngnie-Teta I, Receveur O, Kuate-Defo B. Risk factors for moderate to severe anemia among children in Benin and Mali: insights from a multilevel analysis. Food and Nutrition Bulletin. 2007, 28 (1):76-89.
14. Kibret KT, Chojenta C, D'Arcy E, Loxton D. Spatial distribution and determinant factors of anaemia among women of reproductive age in Ethiopia: a multilevel and spatial analysis. BMJ open. 2019; 9 (4).
15. Kim R, Choi N, Subramanian SV, Oh J. Service quality beyond access: a multilevel analysis of neonatal, infant, and under-five child mortality using the Indian Demographic and Health Survey 2015~ 2016. Perspectives in Nursing Science. 2018 Oct 1; 15(2):49-69.
16. Goldstein H. Multilevel statistical models. John Wiley & Sons; 2011 Jul 8.
17. Sommet N, Morselli D. Keep calm and learn multilevel logistic modeling: a simplified three-step procedure using Stata, R, mplus, & SPSS. International Review of Social Psychology. 2017; 30: 203-18.

18. Sappani M, Mani T, Asirvatham ES, Joy M, Babu M, Jeyaseelan L. Trends in prevalence and determinants of severe and moderate anaemia among women of reproductive age during the last 15 years in India. Plos one. 2023 Jun 1; 18 (6):e0286464.

19. Sharma H, Singh SK, Srivastava S. Major correlates of anemia among women (age 15–49) in India and spatial variation, evidence from national family health survey-4. J Women's Health Care. 2018; 7 (440):2167.

20. Sedlander E, Long MW, Mohanty S, Munjral A, Bingenheimer JB, Yilma H, Rimal RN. Moving beyond individual barriers and identifying multi-level strategies to reduce anemia in Odisha India. BMC Public Health. 2020 Dec; 20: 1-6.

21. Rammohan A, Awofeso N, Robitaille MC. Addressing female iron-deficiency anaemia in india: is vegetarianism the major obstacle?. International Scholarly Research Notices. 2012; 2012.

22. Barman M. Anaemia Prevalence and Socio-demographic Factors among Women of Reproductive Age (WRA): A Geospatial Analysis of Empowered Action Groups (EAG) States in India.

23. Bhadra P, Deb A. A review on nutritional anemia. Indian Journal of Natural Sciences. 2020; 10 (59): 18466-74.

24. Haldar P, Kant S, Yadav V, Majhi J, Malhotra S, Kaur R, Kumar R, Singh AK, Archana S, Lohia A, Rath R. Effect of intravenous iron sucrose on hemoglobin level, when administered in a standard-dose, to anemic pregnant women in rural Northern India. Journal of family medicine and primary care. 2018 Jul; 7 (4):762.

25. Shah AR, Subramanyam MA. Community-level women's education and undernutrition among Indian adolescents: A multilevel analysis of a national survey. Plos one. 2021 May 20; 16(5):e0251427.

26. Sharif N, Das B, Alam A. Prevalence of anemia among reproductive women in different social group in India: Cross-sectional study using nationally representative data. Plos one. 2023 Feb 2; 18 (2): e0281015.

27. International Institute for Population Sciences (IIPS) and ICF. (2021). National Family Health Survey (NFHS-5), 2019–21: India. National Family Health Survey, India.

28. Li D, Sinclair AJ, Mann NJ, Turner A, Ball MJ. Selected micronutrient intake and status in men with differing meat intakes, vegetarians and vegans. Asia Pacific Journal of Clinical Nutrition. 2000 Mar 27; 9(1):18-23.

29. Elorinne AL, Alfthan G, Erlund I, Kivimäki H, Paju A, Salminen I, Turpeinen U, Voutilainen S, Laakso J. Food and nutrient intake and nutritional status of Finnish vegans and non-vegetarians. PloS one. 2016 Feb 3; 11(2):e0148235.

Citation: Rahman SS, Dubey PK, Vishwakarma M, Ruma Talukdar R. Barriers and Facilitators Contributing to Anemia among women in Northeast India: A multilevel modelling approach. Indian J Prev Soc Med, 2024; 55 (3): **205-215.**