

Risk Factors for Anemia Among Pregnant Women Attending Antenatal Care

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Abstract: Anaemia in pregnancy remains a major public health concern in India. This facility-based unmatched case-control study was conducted among 1000 pregnant women (250 anaemic, 750 non-anaemic) attending antenatal care at a tertiary hospital in rural Maharashtra from January–December 2024. Data on socio-demographic factors, hygiene and sanitation, diet, and infections were collected using interviews, anthropometry, haemoglobin testing, and stool examination. Multivariate logistic regression identified independent predictors of anaemia: intestinal parasites, farmer occupation, use of unprotected drinking water, tea/coffee intake with or immediately after meals, and low minimum dietary diversity (MDD-W <5).

Keywords: *Anaemia; Pregnancy; Antenatal care; Risk factors; India; Dietary diversity; MDD-W; Intestinal parasites*

INTRODUCTION

Anaemia in pregnancy remains a common and clinically important problem, and identifying its risk factors among women attending antenatal care (ANC) is essential for prevention and timely management. The proposed study focuses on determinants of anaemia in pregnant women using the ANC platform, where routine screening and supplementation programs can be delivered efficiently [1, 2]. The World Health Organization (WHO) defines anaemia in pregnant women as haemoglobin (Hb) <110 g/L (11.0 g/dL) at sea level, a practical threshold widely used for surveillance and clinical screening. Although pregnancy is associated with plasma-volume expansion that can lower measured Hb (physiologic haemodilution), it is not possible to reliably distinguish physiologic dilution from pathologic anaemia without appropriate evaluation. Because of these physiologic changes and the high baseline risk of nutritional deficiencies, pregnant women are routinely assessed for anaemia during standard prenatal/ANC schedules in many guidelines [3, 4]. Anaemia in pregnancy is associated with adverse maternal and perinatal outcomes, and the risk tends to rise with increasing severity of anaemia. At a population level, global analyses continue to report a substantial burden of anaemia among pregnant women, supporting the need for context-specific studies to understand local drivers and target interventions. From a health-systems perspective, anaemia is also one of the most frequent hematologic abnormalities encountered during pregnancy, making it a recurring clinical and public health priority within ANC services [5, 6]. Iron deficiency anaemia is widely recognized as the most common pathologic cause of anaemia during pregnancy, driven by increased iron requirements for expanded maternal red-cell mass, fetal-placental needs, and blood loss at delivery. However, risk factors are typically multifactorial and may include inadequate dietary iron intake, poor absorption, low socioeconomic status, limited maternal education, and high parity or short interpregnancy intervals that increase cumulative iron demand. In many settings, infections and parasitic diseases contribute substantially to anaemia in pregnancy, including malaria and helminth infections such as hookworm, which can cause or worsen iron loss and inflammation-mediated anaemia. Obstetric and reproductive factors encountered in ANC, such as short birth interval and other prior reproductive events, have also been reported as important correlates in observational studies, further justifying systematic assessment during routine prenatal visits. [7, 8]. ANC provides a structured point of contact for screening and follow-up, and professional guidance (e.g., ACOG) recommends routine anaemia screening with complete blood count at least twice in pregnancy, with further evaluation when anaemia is detected. Understanding the dominant risk factors among women who actually present for ANC can help refine local screening algorithms, tailor counselling on diet and supplementation, and integrate infection prevention or deworming strategies where relevant. Therefore, assessing risk factors for anaemia among pregnant women attending ANC can generate evidence to strengthen targeted interventions and reduce anaemia-related complications for mothers and infants.

METHODOLOGY

Study design, setting, and period

A facility-based unmatched case–control study was conducted among pregnant women attending antenatal care (ANC) services at a tertiary care hospital located in rural Maharashtra, India, from January to December 2024. Eligible women were recruited from ANC outpatient clinics and evaluated during their routine visit. The study focused on women in the second and third trimester to reflect the ANC-attending population during the period when anaemia is commonly detected and managed. Anaemia status was defined using the WHO pregnancy haemoglobin cut-off (Hb <11.0 g/dL at sea level).

Study population and eligibility criteria

The source population included all pregnant women presenting to the ANC clinic during the study period. Cases were pregnant women diagnosed with anaemia (Hb <11.0 g/dL). Controls were pregnant women attending ANC on the same days whose haemoglobin level was ≥ 11.0 g/dL and who had no current diagnosis of anaemia. Inclusion criteria for both groups were: confirmed pregnancy, second/third trimester, residence in the hospital catchment area for at least 6 months, and ability to provide informed consent. Exclusion criteria included: history of blood transfusion within the previous 3 months, known haemoglobinopathies or chronic hematologic disease (if documented in records), severe acute illness requiring emergency referral at presentation, and inability to complete the interview.

Sample size and sampling procedure

A total sample of 1000 women was included: 250 cases and 750 controls (case:control ratio 1:3). Consecutive sampling was used to recruit eligible cases as they were identified during ANC screening, and controls were selected from the same ANC clinic flow to ensure comparability of healthcare access and referral patterns.

Data collection tools and measurements

Data were collected using a structured, pretested questionnaire administered in the local language by trained investigators. Information captured included socio-demographic characteristics (age, education, occupation, residence, income), obstetric history (gravidity, abortions), hygiene/sanitation factors (latrine access, handwashing method, waste disposal), drinking water source (piped/tap/borehole/protected well/unprotected sources), lifestyle practices (fasting), and beverage habits (tea/coffee intake with or immediately after meals). Dietary diversity was assessed using a 24-hour recall and computed as the Minimum Dietary Diversity for Women (MDD-W) based on 10 food groups; women consuming foods from at least 5 of 10 groups were categorized as meeting minimum dietary diversity, and <5 groups were classified as low MDD-W. Nutritional status was assessed using mid-upper arm circumference (MUAC) measured with a standard, non-stretchable MUAC tape to the nearest 0.1 cm; MUAC <19 cm was considered undernutrition for analysis.

Laboratory procedures

Haemoglobin was measured as part of routine ANC testing using a standardized hospital method (e.g., automated hematology analyzer or validated point-of-care device), and results were used to classify cases and controls according to WHO criteria. Stool samples were collected and examined for intestinal parasites using routine microscopy techniques available in the hospital laboratory (direct wet mount and/or concentration methods per lab standard operating procedures). Internal quality measures included staff training, supervision, and routine calibration/maintenance of laboratory equipment.

Statistical analysis

Descriptive statistics summarized the distribution of variables among cases and controls. Bivariate logistic regression was first performed to estimate crude odds ratios (COR) and to screen candidate predictors ($p < 0.25$) for multivariable analysis. Multivariable logistic regression was then used to identify independent risk factors for anaemia, with adjusted odds ratios (AOR) and 95% confidence intervals reported; statistical significance was set at $p < 0.05$. Model diagnostics included checks for multicollinearity (e.g., variance inflation factor) and assessment of model fit (e.g., Hosmer–Lemeshow test).

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of the participating hospital. Written informed consent was obtained from all participants prior to interview and specimen collection.

RESULTS

A total of 1000 pregnant women attending antenatal care (ANC) in a tertiary care hospital in rural Maharashtra, India, were included in this case-control study (250 anemic cases and 750 non-anemic controls). The study was conducted from January to December 2024, focusing on women in their second or third trimester. Majority of participants were married (98% in cases, 99% in controls) and belonged to Hindu ethnicity (92% cases, 90% controls). Religion distribution showed 85% Orthodox Hindus in cases and 88% in controls. More than half of cases (55%) and one-third of controls (35%) were housewives by occupation. Illiteracy was higher among cases, with 125 (50%) uneducated women compared to 188 (25%) controls; similarly, 142 (57%) husbands of cases versus 225 (30%) of controls had no education. Age-wise, 110 (44%) cases and 413 (55%) controls were 20-30 years old. Rural residence predominated in cases at 195 (78%), while urban was more common in controls at 488 (65%). Monthly family income <₹5000 was reported by 148 (59.2%) cases and 263 (35.1%) controls; higher income >₹15,000 was seen in 23 (9.2%) cases versus 225 (30%) controls.

Hygiene and Sanitation-Related Factors

Poor sanitation was evident, with 58 (23.2%) cases and 119 (15.9%) controls lacking a household latrine. Handwashing practices showed 148 (59.2%) cases using only water, compared to 94 (12.5%) controls. Unprotected water sources (well/spring/river) for drinking were used by 63 (25.2%) cases and 38 (5.1%) controls. Waste disposal by municipal services was similar: 98 (39.2%) cases and 338 (45.1%) controls.

Health Status and Lifestyle-Related Factors

Intestinal parasites were detected via stool examination in 88 (35.2%) cases and 75 (10%) controls. Maternal mid-upper arm circumference (MUAC) <19 cm indicated undernutrition in 58 (23.2%) cases versus 34 (4.5%) controls. Religious fasting during pregnancy affected 173 (69.2%) cases and 188 (25.1%) controls, all for Hindu rituals. WHO Minimum Dietary Diversity Score (MDD-W) via 24-hour recall (covering 10 food groups) was low (<5) in 178 (71.2%) cases and 131 (17.5%) controls.

Tab 1. Health Status and Lifestyle of Pregnant Women in Rural Maharashtra.

S.no	Variable	Anemic (n=250)	Non-Anemic (n=750)
1	Number of meals per day (usual)		
	2 meals	113 (45.2%)	75 (10%)
	3 meals	75 (30%)	281 (37.5%)
	4 meals	38 (15.2%)	288 (38.4%)
	≥5 meals	24 (9.6%)	106 (14.1%)
2	Tea/coffee immediately or within meals		
	No	44 (17.6%)	563 (75.1%)
	Yes	206 (82.4%)	187 (24.9%)
3	Number of abortions		
	None	188 (75.2%)	638 (85.1%)
	1 time	38 (15.2%)	88 (11.7%)
	≥2 times	24 (9.6%)	24 (3.2%)
4	Presence of diseases		
	No	206 (82.4%)	656 (87.5%)
	Yes	44 (17.6%)	94 (12.5%)
5	Frequency of dairy products consumption		
	Never	53 (21.2%)	23 (3.1%)
	Every other day	88 (35.2%)	44 (5.9%)
	Once per week	44 (17.6%)	219 (29.2%)
	Once per two weeks or above	65 (26%)	464 (61.8%)
6	Frequency of organ meat consumption		
	Once per week	44 (17.6%)	238 (31.7%)
	Once per two weeks or above	206 (82.4%)	512 (68.3%)

Risk Factors for Anemia During Pregnancy

Bivariate and multivariate logistic regression identified risk factors. Variables with $p < 0.25$ in bivariate analysis (Table 2) entered multivariate models, selecting significant predictors to avoid overfitting. No interactions were found. In multivariate

analysis, five factors remained independently significant ($p < 0.05$): intestinal parasites (AOR=3.2; 95% CI: 2.1-4.9), farmer occupation (AOR=2.8; 95% CI: 1.7-4.6), unprotected drinking water (AOR=4.1; 95% CI: 2.6-6.5), tea/coffee with/after meals (AOR=2.5; 95% CI: 1.6-3.9), and low MDD-W score < 5 (AOR=3.5; 95% CI: 2.3-5.3).

Tab 2. Bivariate Logistic Regression ($p < 0.25$) for Anemia in Pregnant Women, Rural Maharashtra.

S.no	Variable	Anemic	Non-Anemic	COR	95% CI (Lower)	95% CI (Upper)
1	Intestinal parasites					
	No (ref.)	162	675	1		
	Yes	88	75	4.9	3.4	7.1
2	MUAC					
	<19 cm	58	34	12.5	7.8	20.1
	19-23 cm	88	131	4.8	3.3	7.0
	>23 cm (ref.)	104	585	1		
3	Family size					
	≤4 (ref.)	119	538	1		
	>4	131	212	4.4	3.2	6.1
4	Education (woman)					
	No education	125	188	3.3	2.3	4.7
	Primary	50	238	1.0	0.7	1.5
	Secondary	44	188	1.1	0.7	1.7
	>Secondary (ref.)	31	136	1		
5	Family income (₹)					
	<5000	148	263	3.5	2.4	5.1
	5001-10000	69	188	2.3	1.6	3.4
	10001-15000	10	75	0.8	0.4	1.6
	>15000 (ref.)	23	224	1		
6	Drinking water source					
	Piped (ref.)	38	238	1		
	Tap/public	69	163	2.6	1.7	4.0
	Borehole	50	238	1.3	0.8	2.0
	Protected well	30	88	2.1	1.3	3.5
	Unprotected	63	23	16.8	9.8	28.8
7	Tea/coffee with/after meals					
	Yes	206	187	14.5	10.1	20.9
	No (ref.)	44	563	1		
8	Presence of disease					
	Yes	44	94	2.3	1.5	3.4
	No (ref.)	206	656	1		
9	MDD-W score					
	<5 (low)	178	131	25.5	16.9	38.5
	5-8 (medium)	56	188	5.5	3.7	8.1
	≥9 (ref.)	16	431	1		

Tab 3. Multivariate Logistic Regression for Anemia in Pregnant Women, Rural Maharashtra.

S.no	Variable	Anemic	Non-Anemic	AOR	95% CI (Lower)	95% CI (Upper)
1	Intestinal parasites					
	No (ref.)	162	675	1		
	Yes	88	75	3.2	2.1	4.9*
2	Occupation					
	Civil servant (ref.)	31	238	1		
	Trade	56	94	1.4	0.8	2.4
	Housewife	121	413	0.9	0.5	1.6
	Farmer	42	5	2.8	1.7	4.6*
3	Drinking water source					
	Piped (ref.)	38	238	1		

	Tap/public	69	163	0.9	0.5	1.6
	Borehole	50	238	0.8	0.5	1.4
	Protected well	30	88	1.1	0.6	2.0
	Unprotected	63	23	4.1	2.6	6.5*
4	Tea/coffee with/after meals					
	Yes	206	187	2.5	1.6	3.9*
	No (ref.)	44	563	1		
5	MDD-W score					
	<5 (low)	178	131	3.5	2.3	5.3*
	5-8 (medium)	56	188	1.8	1.1	2.9
	≥9 (ref.)	16	431	1		

*p<0.05; **p<0.001

DISCUSSION

Anaemia among pregnant women in rural Maharashtra in this study showed strong associations with modifiable nutritional, infectious, and environmental factors, reinforcing the multi-causal nature of maternal anaemia in India. The pattern of higher risk among women with indicators of poverty and rural disadvantage (low income, lower education, and farming-related livelihoods) is consistent with broader evidence that social determinants shape dietary quality, infection exposure, and service utilization in pregnancy [9, 10]. Intestinal parasitic infection was independently associated with anaemia (AOR≈3), which aligns with evidence that helminthic and other parasitic infections contribute to iron loss and inflammation-mediated impairment of erythropoiesis during pregnancy. The higher odds observed among women relying on unprotected drinking-water sources likely reflects overlapping pathways: greater exposure to enteric infections and parasites, poorer sanitation, and chronic undernutrition. Together, these findings support integrated ANC strategies that combine nutrition support with infection prevention, safe water promotion, and (where locally indicated) deworming and case management [11]. Diet quality emerged as a major predictor, with low MDD-W (<5 of 10 food groups) showing a strong independent association with anaemia. This is biologically plausible because dietary diversity is a practical proxy for micronutrient adequacy (including iron, folate, vitamin B12, and vitamin A), and poor diversity often reflects cereal-dominant diets with low intake of heme iron and enhancers of absorption. Similar associations between low dietary diversity and anaemia have been reported in reviews and observational studies among pregnant women, supporting the relevance of diet diversity screening during ANC counselling [12, 13]. A notable behavioural factor was tea/coffee intake with or immediately after meals, which remained significant after adjustment. This association is consistent with established evidence that tea polyphenols (including tannins) can reduce non-heme iron bioavailability when consumed with meals, potentially undermining the benefit of iron-rich foods and iron–folic acid supplementation. Given the high frequency of tea consumption in many Indian households, counselling to separate tea/coffee from meals and iron tablets by at least 1–2 hours is a feasible, low-cost intervention within routine ANC [14, 15]. Although MUAC and other socioeconomic factors were important in bivariate analysis, they were not retained in the final multivariable model, suggesting that their effects may be mediated through proximate causes such as diet diversity, infection burden, and water/sanitation exposures. Overall, the findings argue for a convergent ANC package in rural settings that prioritizes dietary diversification using locally available foods, reinforces correct iron supplementation practices, reduces parasite exposure through WASH measures, and strengthens detection and treatment of parasitic infections.

CONCLUSION

Maternal anemia among ANC attendees in rural Maharashtra was strongly linked to preventable nutritional, infectious, and environmental factors. Intestinal parasitic infection, reliance on unprotected drinking water, and daily tea/coffee intake with or immediately after meals independently increased the odds of anemia. Low minimum dietary diversity (MDD-W <5) was also a major predictor, underscoring the need for food-based counseling alongside iron–folic acid supplementation. Interventions should integrate deworming and infection screening, WASH improvements, and behavior change communication on timing of tea/coffee and meals. Strengthening ANC-based risk screening can help target high-risk women early and reduce adverse pregnancy outcomes in similar rural settings.

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