Salud, Ciencia y Tecnología. 2025; 5:1906
doi: 10.56294/saludcyt20251906

ORIGINAL

Assessment of anemia prevalence, predictors, contributing factors, and knowledge among Indigenous tribes in Tamil Nadu, India

Evaluación de la prevalencia de la anemia, predictores, factores contribuyentes y conocimientos entre las tribus indígenas de Tamil Nadu, India

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Cite as: Panneer Selvam K, Kosalram K, Ganesh Pichamuthu B. Assessment of anemia prevalence, predictors, contributing factors, and knowledge among Indigenous tribes in Tamil Nadu, India. Salud, Ciencia y Tecnología. 2025; 5:1906. https://doi.org/10.56294/saludcyt20251906

Submitted: 25-01-2025 **Revised:** 17-04-2025 **Accepted:** 15-07-2025 **Published:** 16-07-2025

Editor: Prof. Dr. William Castillo-González

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ABSTRACT

Introduction: anemia is a significant public health issue worldwide, particularly among Indigenous populations, because of numerous nutritional, genetic, and socio-cultural reasons. Among the Malayali tribes of Tamil Nadu, India—a Scheduled Tribe with a history of consanguineous marriage and limited access to healthcare—there is a high burden of anemia, but little has been established about the issue.
Method: community-based cross-sectional study was carried out among 516 respondents. Hematological profiling and Semi-structured questionnaire was utilized to collect socio-demographic indicators, morbidity history and anemia specific knowledge. Binary logistic regression analysis and Chi-square tests were utilized to study associations between demographic factors and anemia.
Results: the overall prevalence of anemia in the current study was 38 %, and the prevalence proportion of severe anemia was 2,3 %, moderate anemia was 22,5 %, and mild anemia was 13,2 %.Logistic regression analysis revealed significant odds of anemia in men (aOR=0,48, 95 % CI: 0,32-0,71), unmarried persons (aOR=0,33, 95 % CI: 0,12-0,88), students (aOR=3,46, 95 % CI: 1,23-9,76), and household members (aOR=0,46, 95 % CI: 0,27-0,80).
Conclusion: compared to the other Indian tribal communities, the anemia prevalence in the Malayali tribe is lower but still a public health problem for the latter and others. Hematological profiling can aid in the diagnosis of conditions in tribal, remote environments where laboratory-based diagnostic capacity could be limited. Aside from education and participant age, socioeconomic and gendered work factors seemed to have the most influence on risk factors for anemia.

Keywords: Anemia; Indigenous Health; Hematological Profiling; Tribal Populations; Malayali Tribes.

RESUMEN

Introducción: la anemia es un importante problema de salud pública a nivel mundial, especialmente entre las poblaciones indígenas, debido a diversas causas nutricionales, genéticas y socioculturales. Entre las tribus Malayali de Tamil Nadu, India—una comunidad clasificada como tribu registrada con antecedentes de matrimonios consanguíneos y acceso limitado a servicios de salud—existe una alta carga de anemia, pero poco se ha documentado al respecto.
Método: se realizó un estudio transversal comunitario con la participación de 516 personas. Se emplearon perfiles hematológicos y un cuestionario semiestructurado para recopilar datos sobre indicadores sociodemográficos,

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antecedentes de morbilidad y conocimientos específicos sobre la anemia. Se utilizaron pruebas de Chi-cuadrado y regresión logística binaria para analizar las asociaciones entre factores demográficos y anemia.
Resultados: la prevalencia general de anemia en este estudio fue del 38 %; la anemia grave representó el 2,3 %, la anemia moderada el 22,5 % y la anemia leve el 13,2 %. El análisis de regresión logística reveló mayores probabilidades de anemia en estudiantes (ORa=3,46; IC 95 %: 1,23–9,76) y menores en hombres (ORa=0,48; IC 95 %: 0,32–0,71), personas solteras (ORa=0,33; IC 95 %: 0,12–0,88) y miembros del hogar (ORa=0,46; IC 95 %: 0,27–0,80).
Conclusión: aunque la prevalencia de anemia en la tribu Malayali es menor en comparación con otras comunidades tribales de la India, sigue siendo un problema de salud pública. La utilización del perfil hematológico puede ser útil en contextos remotos con acceso limitado a diagnósticos de laboratorio. Factores socioeconómicos y de género parecen influir significativamente en el riesgo de anemia.

Palabras clave: Anemia; Salud Indígena; Perfil Hematológico; Poblaciones Tribales; Tribus Malayali.

INTRODUCTION

Anemia affects 1,92 billion people, and it remains a universal health issue. As per the Global Burden of Disease (GBD 2021) study, anemia is one of the third-highest causes of disability.[1] People in vulnerable groups, such as tribals, are at higher risk of anemia due to poor literacy rates and strong cultural beliefs.[2] A large field survey in India, NFHS-5, reported that as high as 57 percent of the females at reproductive age and 67 percent of the children have iron deficiency anemia, which highlights the burden on public health in general.[3,4]

Malnutrition is highly prevalent in the context of maternal and child health, addressing the major concern, and this is due to their dependence on the PDS systems, poor food intake, poor income, and illiteracy. The tribals have poor health-seeking behaviour, and socioeconomic conditions play an important role in nutrition status.[5,6,7] Malnutrition is common among tribals due to a lack of iron-rich foods and hookworm infestations.[8] Malayali tribes will come under the Scheduled tribes as per the caste system, and this community has a rich cultural background with good environmental surroundings, but has marked health inequities.[9] These tribals' main jobs are hunting and agriculture, but it is now changed, and their lifestyle has changed as well. Despite various governmental schemes aimed at improving tribal health, anemia prevalence in these communities remains alarmingly high and understudied.[10] Some studies provided the anemia rates in Madhya Pradesh as 76,7 %,[11] 64 % prevalence among Tharu tribal women.[12] A study in Kerala revealed that 88 % of the school children in tribal areas are anemic.[13]

For the above studies, it is evident that the existing literature has largely focused on women and children in urban or semi-urban populations, with limited data on adult tribal populations, particularly with comprehensive hematological profiling.[14,15] Recent studies urge the need for the use of complete blood count to find out the difference between nutritional anemia and other genetic disorders for the assessment of anemia in tribal regions.[16,17,12] However, several studies have found the relationship between anemia among tribal communities and demographic characteristics, comorbidities, and awareness in Tamil Nadu, India.[18,19,20]

The reasons for anemia are the lack of RBC production or the loss of blood. The normal values for the Hemoglobin concentration are classified as mild (11 to 11,9) gm/dl, moderate(8 to 10,9) gm/dl and for severe less than 8 gm/ dl are for women and men mild(11 to 12,9) and severe less than 8, moderate (8 to 10,9) gm/ dl.[16] The data related to the particularly vulnerable tribal group on anemia and other nutritional problems is challenging for policy-level decision-making.[7] WHO has targeted to reduce anemia by 2030, and many countries have not been able to address In India, despite the national programs like Anaemia Mukt Bharat (AMB) and the AMB strategy, it is still a concern and which was highlighted in NFHS 4 AND NFHS 5, where the trend has increased.[21]

In the NFHS survey during the recent phase, there is the possibility of overestimation of anemia, and the reason for this is the use of capillary blood testing methods.[22] This research tries to fill the gap by adopting a standardized blood testing procedure and a proper sampling method to estimate the prevalence in a vulnerable tribal community where thalassemia and sickle anemia are high. The present study aims to find the prevalence of anemia among Malayali tribes in Sitter Panchayat by using haematological profiling and with structured questionnaire.[23,24,25]

METHOD

Study Design and Setting: this cross-sectional community-based study was carried out in Sitteri Panchayat, Dharmapuri district, Tamil Nadu, India, between January and July 2021. The population studied was Malayali tribal individuals who are a Scheduled Tribe known to have a past history of high consanguinity and restricted access to health care services.

Study Population and Sampling: the target population consisted of study participants who were 2 to 60 years old, male and female. Participants were excluded if they had profound cognitive impairment or had a documented family history of sickle cell anemia or thalassemia. The sample size was determined by the formula $n = Z^2 \times p\ (1-p) / d^2$, we took 50 % prevalence with 5 % margin error and 95 % confidence level and an additional 20 % non-respondents, the sample size was fixed at 516. Multistage random sampling technique was employed. To provide equal representation of all regions, four villages were randomly chosen out of the thirteen villages of Sitteri Panchayat. In villages, randomly selected households and those individuals who were available (and agreed to participate) at the time of visit were taken into account. Out of 530 individuals approached, 516 agreed to participate (response rate 97,3 %).

Data Collection Instruments and Variables: data collection included two components; (1) hematological profiling, and (2) semi-structured questionnaire. The semi-structured questionnaire yielded the following information: socio-demographic variables (age, sex, marital status, education, occupation, income, consanguinity) and data on history of morbidity and information regarding Anemia knowledge. Knowledge was a subscale of a validated measure used earlier that was shown to have sufficient reliability and internal consistency (Cronbach's alpha = 0,80; $p < 0,01$), and higher scores in that section of the questionnaire were associated with greater knowledge. Laboratory Procedures:A phlebotomist drew 3 ml of venous blood in an EDTA tube.

On collection, the samples were conveyed to the laboratory in a perfusion unit in accordance with cold chain standards. The sample was examined immediately after using a SYSMEX POCH-100i Automated Hematology Analyzer. Parameters analyzed as a part of the complete blood count (CBC) included Hemoglobin (HGB), Red Blood Cell Count (RBC), Hematocrit (HCT), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), and Red Cell Distribution Width (RDW). These cut-off values were used for adult reference intervals: HGB, males 13,5 – 17,5 g/dL, females 12,0 – 15,5 g/dL, RBC, males 4,5 – 5,9 million/µL, females 4,1 – 5,1 million/µL, HCT, males 41 – 50 %, females 36 – 44 %, MCV, 80-100 fL, MCH, 27-33 pg, MCHC, 33,0 – 36,0 g/dL, and RDW, 11,5 – 14,5 %. In both instances, Iron Deficiency anemia was defined by a rise in RDW and fall in RBC, MCV, and MCH, whereas Vitamin B12 Deficiency anemia was defined by rising MCV, MCH, and RDW. There was also a fall in RBC levels.

Statistical Analysis information was captured in Microsoft Excel and analyzed with SPSS version 26,0. The socio-demographic variables and prevalence of anemia were computed using descriptive statistics. Relationships of the categorical variables with anemia status were examined using chi-square tests. Logistic binary regression was conducted to determine predictors of anemia, presenting adjusted odds ratios (aORs) with 95 % confidence intervals (CIs).

Ethical Considerations: from 2018-2020, Institutional Review Board and Ethics Committee (IRB Reg. No: IR800008555) ethical approvals were sought. Written informed consent was signed by participants prior to data collection.

RESULTS

Table 1. Socio-demographic characteristics of the respondents

S.No	Characteristics	Character	Frequency	Percentage
1	Marital Status	Married	253	49
		Unmarried	263	51
2	Consanguinity	No	180	71
		Yes	73	29
3	Education	No Formal Education	123	24
		Primary (1 to 5th Std)	162	31
		Secondary(6th to 10th std)	168	33
		Under graduate	63	12
4	Occupation	Employed	79	15
		Farmer	209	41
		Student	228	44
5	Gender	Female	278	54
		Male	238	46
6	Age Classification	2 to 14 Years	155	30
		15 to 24 Years	141	27
		Above 25 Years	220	43

As per table 1, the male and female respondents are equally distributed. About 29 percent of the respondents

are married with consanguinity. Only 12 percent of the respondents have a university degree. About 40 percent do farming and above 25 years are above 25 years of age.

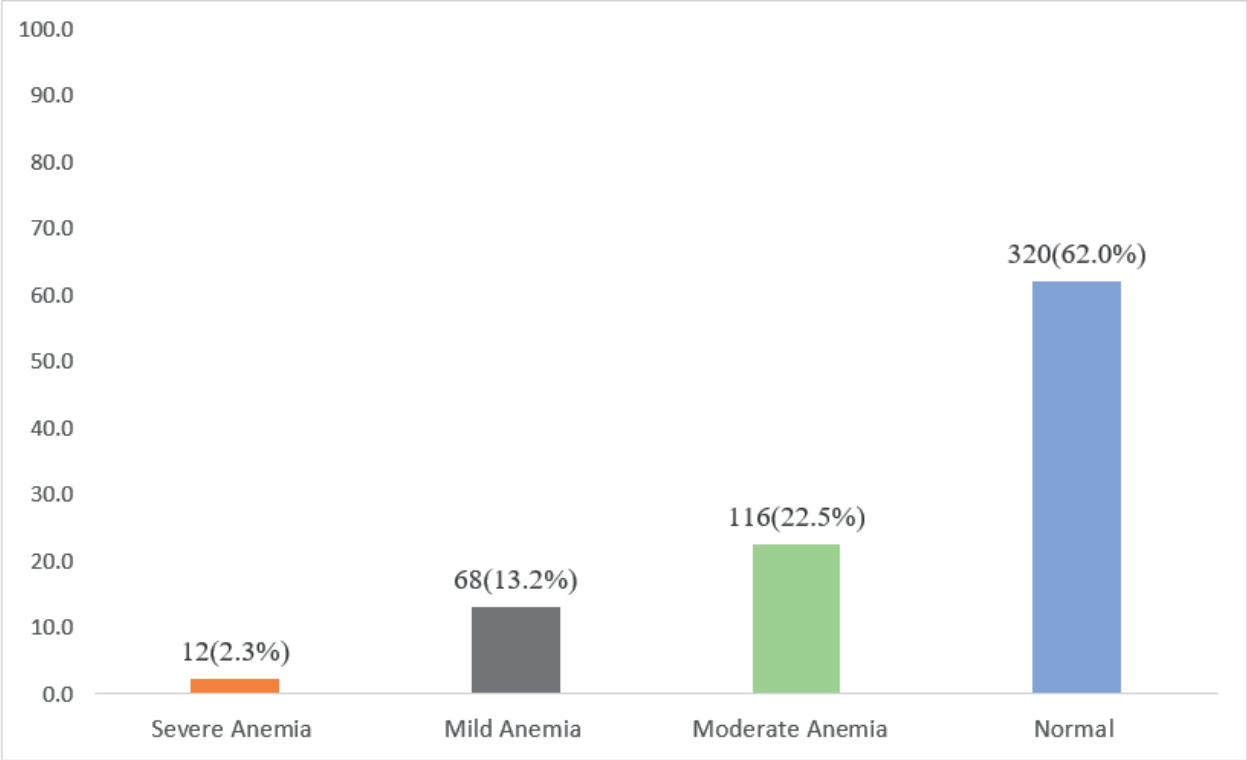

Figure 1. Prevalence of types of anemia by demographic characteristics

As per figure 1, about 2,3 % of the respondents have severe anemia, 13,2 % have mild anemia, and 22,5 % of the respondents have moderate anemia.

Table 2. Association between demographic characteristics and severity of Anemia

S.No	Characteristics	Character	Severe Anemia (Hb <8 g/dl)	Moderate Anemia(8 - 10,9 g/dl)	Mild Anemia(11 -11,4 g/dl)	Normal	Chi-Square Value	P.Value
1	Marital Status	Married	9(3,6 %)	67(26,5 %)	26(10,3 %)	151(59,4 %)	10,38	0,016
		Unmarried	3(1,1 %)	49(18,6 %)	42(16 %)	169(64,3 %)		
2	Age Classification	2 to 14 Years	2(1,3 %)	29(18,7 %)	28(18,1 %)	96(61,9 %)	9,778	0,134
		15 to 24 Years	3(2,1 %)	34(24,1 %)	21(14,9 %)	83(58,9 %)		
		Above 25 Years	7(3,2 %)	53(24,1 %)	19(8,6 %)	141(64,1 %)		
3	Gender	Female	10(3,6 %)	78(28,1 %)	41(14,7 %)	149(53,6 %)	20,544	0,001
		Male	2(0,8 %)	38(16 %)	27(11,3 %)	171(71,8 %)		
4	Occupation	Employed	1(1,3 %)	15(19 %)	3(3,8 %)	60(75,9 %)	21,03	0,002
		Farmer	9(4,3 %)	56(26,8 %)	25(12 %)	119(56,9 %)		
		Student	2(0,9 %)	45(19,7 %)	40(17,5 %)	141(61,8 %)		
5	Education Qualification	No Formal Education	4 (33 %)	29(23,6 %)	18(14,6 %)	72(58,5 %)	6,128	0,727
		Primary(1st to 5th Std)	3(1,9 %)	38(23,5 %)	19(11,7 %)	102(63 %)		
		Secondary(6th to 10th std)	2(1,2 %)	38(22,6 %)	25(14,9 %)	103(61,3 %)		
		Under Graduate	3(4,8 %)	11(17,5 %)	6(9,5 %)	43(68,3 %)		
6	Knowledge on Anemia	High	6(8,5 %)	21(29,6 %)	6(8,5 %)	38(53,5 %)	17,480	0,001
		Low	6(1,3 %)	95(21,3 %)	62(13,9 %)	282(63,4 %)		

As shown in table 2, statistically significant correlations existed between marital status (p = 0,016), gender (p = 0,001), occupation (p = 0,002), and anemia knowledge (p = 0,001) and anemia status. Women and farmers had increased prevalence of moderate and severe anemia. Those with low knowledge regarding anemia also

indicated more common anemia. Education level and age were not statistically significantly correlated with anemia status (p>0,05).

Table 3. Binary Logistic Regression

S.No	Variable	aOR	95 % CI	*p*-value
1	Age			
	3 to 14 Years		reference	
	16 to 24 Years	0,96	(0,51 – 1,84)	0,913
	Above 25 Years	0,48	(0,20 – 1,13)	0,094
2	Sex			
	Female		reference	
	Male	0,48***	(0,32 – 0,71)	<,001
3	Marital Status			
	Married		reference	
	Unmarried	0,33**	(0,12 – 0,88)	0,027
5	Consanguinity			
	No		reference	
	Yes	1,61	(0,88 – 2,96)	0,125
6	Educational Background			
	No Formal Education		reference	
	Primary (1 to 5th Std)	0,7	(0,37 – 1,32)	0,269
	Secondary (6th to 10th std)	0,74	(0,41 – 1,33)	0,307
	University	0,64	(0,30 – 1,37)	0,246
7	Occupation			
	Employed		reference	
	Farmer	1,98**	(1,03 – 3,81)	0,04
	Student	3,46**	(1,23 – 9,76)	0,019
8	Family Members			
	<=5 members		reference	
	>5 members	0,46**	(0,27 – 0,80)	0,006
9	Family had serious Illness in the past one year			
	No		reference	
	Yes	1	(0,65 – 1,54)	0,985
10	Heard About Sickle cell/Thalassemia			
	High Knowledge		reference	
	Low Knowledge	0,57	(0,32 – 1,02)	0,059

Note: ** Significant

As per table 3, the total model was statistically significant (Omnibus Test of Model Coefficients: $x^2 = 52,63$, df = 17, p < 0,001), thus, indicating the model was statistically significant at predicting the outcome variable in the model, relative to the null model. The -2 Log Likelihood of the final model was 565,21, which indicated the final model fit the observed data relative to the baseline model fit much better. The pseudo R-squared values were Cox & Snell $R^2 = 0,091$, Nagelkerke $R^2 = 0,123$, the implications of these were that the model accounted for between 9,1 % and 12,3 % of the variation in anemia status. The model as a whole was correct in 65,5 % of cases. Logistic regression analysis results with adjusted odds ratio (aOR), 95 % confidence intervals (CIs), and respective p-values for each variable are given in the table above.

Age was not found to be associated with anemia, and the respondents with age group 16 to 24 years have aOR = 0,96 (95 % CI: 0,51–1,84; p = 0,913), and those above 25 years had aOR = 0,48 (95 % CI: 0,20–1,13; p = 0,094), compared to those aged 3–14 years. Female respondents had higher odds compared to males, and a significant association was found (aOR = 0,48, 95 % CI: 0,32–0,71; p < 0,001). Married respondents have higher odds and are found to be associated when compared with unmarried respondents (aOR = 0,33, 95 % CI: 0,12–0,88; p = 0,027). Participants with consanguineous marriage have higher odds of having anemia when compared, but it

was not statistically significant. Education did not show a significant association, but university students have lower odds of having anemia.

Occupation and family size were significantly associated with anemia. Employed individuals and farmers have twice the odds of having anemia (aOR = 1,98, 95 % CI: 1,03–3,81; p = 0,040), the higher the family size the lower the odds of having anemia (aOR = 0,46, 95 % CI: 0,27–0,80; p = 0,006). Morbidity and knowledge on anemia have not shown a significant association.

DISCUSSION

Anemia prevalence rate among the Malayali tribe in Sitteri is found to be 38 %, and it aligns with the global standards of prevalence among tribals,[26,27] and accounts for a moderately high public health problem. Our research revealed that nearly half of the women, 46,7 %, were anemic, which is marginally lower than the 53 % reported at the state level according to NFHS-5 data for Tamil Nadu.[4] Despite government interventions to address anemia among women through MCH and IFA supplementation program services, the utilization of the services is very low among the tribals.[28,29] This was greatly reflected in NFHS data, which indicates that the odds of being anaemic are significantly higher when the status is scheduled tribe, compared to not being anaemic (both male and female).[30]

Our tribal community's anemia status was better when compared with other tribal communities of some having as high as >90 % anemia rates among their female population in Odhisha state, Particularly Vulnerable Tribal Groups (PVTGs).(7) Compared to NFHS-4, 2015-16 data among Odisha tribal women, a female anemia prevalence of 59,9 % was reported and which still makes us suspect that tribal women of Odisha PVTG have significantly higher anemia prevalence without exhausting any other depth of their NFHS data, or articles.[31,32]

Similarly, in tribal societies, for example, the Tharu of northern India and Paniya of Kerala, anemia has been reported by large majorities of women, usually 75-90 % across various age groups, with significant numbers of moderate-to-severe anemia cases in women and children.[33,34] These comparisons have stressed that while the burden of anemia is great in the case of the Malayali tribe, it could be less when placed in relative terms to some other more isolated or socioeconomically disadvantaged tribes. The changes in the anemia status of different tribes are attributed to differences in diet (e.g., intake of millets and leafy greens in South India), availability of health care or public nutrition services, and chronic infections reflecting the heterogeneity in tribal populations.[35,36] The prevalence of anemia in our study at a global level (38 % overall) is greater than a 2023 global estimate of 31 % in women and 17 % in men, showing that the inequities of underserved rural communities are widespread, and it's ambitious to meet the World Health Assembly target of reducing the prevalence of anemia among women of reproductive age by 50 % by 2030.[37,38]

South Asia's tribal population of the globe contributes a significant proportion of the global anemia population, and our findings support the fact that rural and indigenous populations in India, and globally, remain a priority to address anemia.[39,40] The use of hematological profiling in the present study through CBC analysis contributes a unique strength to the literature, which is primarily based on capillary hemoglobin (Hb) estimates and questionnaire and survey-based measurements. Venous sampling and automated SYSMEX POCH analysis yield a more precise measurement, with a reported capillary blood method limitation causing an overestimation of anemia in NFHS surveys.[41,42] Notably, though, even if sex and occupation continued to have an important effect after controlling for them, education and age were less critical to anemia prediction. Such a conclusion is supported by recent research on rural Maharashtra tribal health, and in Gujarat, indicating that socio-cultural determinants e.g., dietary habits, gendered labour patterns, intergenerational malnutrition, are more powerful predictors than formal education (i.e., education is one, but many have the experience of malnutrition.[43,44,45]

The higher prevalence among women, and married women to be specifically higher than men, should be attributed to the cumulative impact of their reproductive burden, maternal care, and cultural food prohibitions during menstruation or pregnancy.[46,47,48] Occupational status significantly predicted anemia in our study, with students and farmers having higher odds than employed individuals. This may reflect the irregular dietary intake and poor iron bioavailability in households relying on subsistence farming, which matches observations in central Indian tribal belts.[49,50] Interestingly, lower odds of anemia were seen in larger households (>5 members), possibly indicating better resource pooling or shared caregiving responsibilities, though this contrasts with urban data where larger families face food insecurity.[51]

Despite higher knowledge scores being correlated with lower anemia severity in bivariate analysis, logistic regression did not find knowledge to be a significant predictor. This suggests a disconnect between knowledge and practice, common in health behavior models among indigenous populations.[52] Cultural inertia, food taboos, and poor service utilization likely dilute the impact of awareness alone.[53] This gap necessitates deeper behavioral interventions supported by community health workers and peer educators, as successfully implemented in Chhattisgarh tribal interventions.[54]

Our research is distinctive in its use of biochemical measurement and socio-demographic and knowledge

variables in a far-flung tribal setting, and few other studies have set out this type of synthesis in regard to consideration of social and structural barriers to information about iron. However, design limitations such as being a cross-sectional study and not measuring dietary intake restrict causal inference and nutrient-specific attribution.

CONCLUSION

In conclusion, anemia places a tremendous burden on the Malayali tribals of Tamil Nadu that is compounded by a mix of nutritional, socio-cultural, and even genetic factors. The prevalence is lower than most other tribal groups in India, but remains high and unacceptable in terms of meeting anemia reduction goals at both national and international levels. The WHO has advocated a 50 % anemia reduction by 2030, and India's initiatives, such as the AMB and Sickle Cell Mission, are definitely encouraging steps, but we have highlighted along the way that to realize these aspirations, interventions need to reach the last-mile indigenous villages with context-specific strategies.

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FUNDING

The authors received no funding for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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