International Journal of Community Medicine and Public Health
Mathew AC et al. Int J Community Med Public Health. 2023 Dec;10(12):4743-4750
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20233773

Original Research Article

Prevalence and determinants of anemia among school going children in the state of Tamil Nadu, India: applications of two-level logistic regression model

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Received: 09 August 2023
Accepted: 18 November 2023

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ABSTRACT

Background: Anemia still remains as one of the major public health problems in India despite implementing preventive measures. The objective was to find the prevalence and determinants of anemia among school going children in Tamil Nadu.
Methods: We used the data from the fourth round of district level household survey (DLHS-4) for Tamil Nadu pertaining to the year 2012-13. Our analysis included 23997 children. Descriptive statistics, Random intercept and empty models of two-level logistic regression analysis were used.
Results: The overall prevalence of anemia was found to be 41.4% (95% CI: 40.77%-42.02%). We observed a district level variation on anemia (District level variance=0.1, p<0.001) and the intra class correlation coefficient was 0.0295. The prevalence of anemia was more in coastal districts as compared to non-coastal districts (43.85% vs. 40.18%, p<0.001). Variables that are found to have significant association with anemia on multilevel analysis were younger age (Adjusted odds ratio (AOR)=1.343, 95% CI: 1.270-1.420), female children (AOR=1.462, 95% CI: 1.387-1.541), more than eight family members in the household (AOR=1.120, 95% CI: 1.008-1.245), rural residence (AOR=1.103, 95% CI: 1.038-1.172) and lower standard of living (AOR=1.203, 95% CI: 1.084-1.334).
Conclusions: Half of school going children were anemic in the state. Geospatial distribution of anemia varied significantly. Governments and regional health centres should take adequate measures to avert the consequences of anemia in school going children considering these factors.

Keywords: Anemia, School going children, Prevalence, Hookworm infection, Tamil Nadu

INTRODUCTION

Anemia remains as one of India's major public health problems. The prevalence of anemia is higher in India compared to other developed countries. As per the studies conducted by world health organization in 2007, about 30-50% of anemia in children and other groups are caused by iron deficiency.[1] The deficiency of iron is the most common cause of anemia worldwide.[2] Interestingly, the distribution of this disease is not uniform throughout the world. In some regions, the prevalence of anemia among young children is greater than 50% and even approaches 100% in some localities.[3] In India, one of the critical causes of childhood anemia is the deficiency of iron, linked to low nutritional iron consumption.[4] Lack of vitamin B12 and A, infections with malaria parasite and hookworm infections are some other factors that affect childhood anemia.[5,6] In rural India the level of haemoglobin is connected with the status of iron in children.[7]

The DLHS data provide both national and state level data that gives an opportunity to find out the severity and distribution of anemia and helps to assess the trends and socio-economic determinants of the prevalence of anemia.[8] Therefore, the present study was conducted to explore the prevalence of anemia among school going children by considering the effects of various socio economic and demographic variables taking into account individual and household and contextual level characteristics in the state of Tamil Nadu. The results of the analysis may provide awareness about the necessary steps to be taken to ensure the health and well-being of school going children.[8]

METHODS

Setting and study design

Present study is a cross sectional study and is based on DLHS 4 pertaining to the year 2012-2013 in the state of Tamil Nadu. DLHS is a household survey conducted at the district level by international institute for population sciences (IIPS). DLHS 4 adopted a multi-stage, stratified, probability proportional to size sample with replacement.[9] More detailed information about sampling procedure can be obtained from the DLHS-4 report. Among the entire participants, those participants who are in between the age group (6-17 years) and currently attending school are considered. In the survey data, current educational status and age of the study participants is mentioned. For all the selected households hemoglobin level was measured for all individuals above 6 months of age. For subjects whose age is in between 6 months and 18 years consents were taken from their parent or guardian. The present study used the HemoCue method, which is considered to be a standard method for hemoglobin measurement by the world health organisation for field studies.[8] We studied a total of 23,997 children whose hemoglobin level values were available.

Ethical committee approval

The institutional human ethics committee of PSG institute of medical sciences and research, Coimbatore, gave approval for the study.

Outcome variable

The outcome variable considered in this study was anemia. The severity of anemia was assessed on the basis of haemoglobin levels of study subjects. Haemoglobin levels greater than 11 g/dL was considered as normal level. Hemoglobin levels of 10-10.99 g/dL was considered as mild, 7-9.99 g/dL considered as moderate and less than 7 g/dL was considered as severe anemia.[8]

Independent variables

The individual level factors considered in the study was age, sex and body mass index (BMI). Age in years was categorized as 6-10 and 11-17. Sex of the individuals was classified as male and female. BMI of the individuals was classified as below 18.5, 18.5-24.9, 25-29.9 and 30 and above. Household and contextual level factors considered in the study were family members, household ownership, sanitation facilities, drinking water source and type of locality. Standard of living index (SLI) was measured through wealth index and was classified as low (0-14), medium (15-24) and high (25-67) based on the total score.[10] Family members was classified as less than 4 members, 5-7 members, 8 or more members. Household ownership was classified as owned, rented and others. Sanitation facilities and drinking water source were classified as unimproved and Improved. Type of locality was classified as rural and urban.

Statistical analysis

The relationship between chosen covariates and anemia was analysed using both bivariate and multivariate methods. Weighted prevalence of anemia was initially estimated.[11,12] In bivariate analysis, chi-square test and Z test were used to find out the association between anemia and various factors. In the multivariate analysis, we applied a two-level logistic regression model to examine the risk factors of anemia by reducing the district level effect that exists on the data set. Intra-class correlation coefficient (ICC) was calculated prior to the application of the two-level regression model. The ICC was calculated using the formula,

$$ICC = \frac{var(V_{0j})}{var(V_{0j}) + \pi^2/3}$$

$var(V_{0j})$ is variance of random intercept in the two level empty model. Multilevel regression model is applicable if the variance of the random intercept is statistically significant and the value of ICC is greater than zero.[13]

For this, two phases of the model were fitted. Model-1 was the empty model and it contained only district specific random effects in order to model between district variations in anemia.

The functional form of the empty model is,

$$logit\left(\pi_{i,j}\right) = \alpha_0 + V_{0j},$$

where $logit\left(\pi_{i,j}\right) = P(Y_{ij} = 1)$, α_0 is the (only) fixed effect in the model and V_{0j} is the level 2 residual.

Model-2 was the random intercept model in which individual level factors, household and contextual level factors and intra level interactions were considered. The mathematical form of the model is,

$$logit\left(\pi_{i,j}\right) = \alpha_0 + \beta_{10}x_{ij} + \beta_{01}X_j + V_{0j}$$

where, x_{ij} denotes the observation-related characteristics and X_j denotes cluster-related characteristics. Similarly,

β_{10} is the fixed slope that denotes the average effect of observation related characteristics in the overall sample and β_{01} is the necessarily fixed slope which is the average effect of cluster level characteristics in the overall sample.[14] In addition, we have also looked into the random coefficient model and appropriateness of these two models were tested using Akaike information criteria (AIC) and Bayesian information criteria (BIC), p<0.05 was considered as statistically significant. The whole analysis was performed using SPSS (version 24).

RESULTS

Table 1 shows the weighted percentage distribution of school going children classified as having anemia by its degree. The overall prevalence of anemia was found to be 41.4% (95% CI: 40.77-42.02%). Among the entire study participants 20.9% had mild anemia, 19% had moderate anemia and severe anemia was reported in 1.7% of participants. The proportion of anemic children was larger (45.8%) in the age group 6-10 years than in the age group 11-17 years (38.7%). The prevalence of anemia was higher in female children than in male children. The prevalence of anemia was higher in those children whose BMI was 30 kg/m^2 and above and whose BMI was below 18.5 kg/m^2 compared to whose BMI 18.5 kg/m^2 to 24.9 kg/m^2. The prevalence of anemia was higher when the number of members in family of study participants were 8 or more. The prevalence of anemia was higher for those participants whose sanitation facilities were still unimproved. There was more prevalence of anemia in the rural areas than in the urban areas and the prevalence was higher among participants whose standard of living was low.

We observed a significant (p<0.001) association between districts and the occurrence of anemia (Table 2). The observed district level variance was 0.1, p<0.001 and the intraclass correlation coefficient was 0.0295. This indicates that 2.95% of variations in the prevalence of anemia can be explained by district level factors (Table 3).[15] The prevalence of anemia was more in coastal districts as compared to non-coastal districts (43.85% vs. 40.18%, p<0.001) (Table 4) and (Table 5). It was also observed that there was not much difference neither in standard of living (p=0.423) nor in BMI (p=0.782) between the children residing in the coastal and non-coastal districts. Distribution of the prevalence of anemia across the districts of Tamil Nadu was presented in the Figure 1.

It was observed that random intercept model has AIC=103603 and BIC=103611 whereas random coefficient model has AIC=103757 and BIC=103830. Accordingly, random intercept model was used in our study. The results obtained from this two-level random intercept logistic regression model are displayed in (Table 6). It was observed that younger age group (6-10 years) compared with older age groups (11-17 years) (AOR=1.343, 95% CI: 1.270-1.420), female children when compared with male children (AOR=1.462, 95% CI: 1.387-1.541), rural residence compared with urban residence (AOR=1.103, 95% CI: 1.038-1.172), more than 8 family members in the house compared with 4 or less family members (AOR=1.120, 95% CI: 1.008-1.245), 5to7 members in the family compared with 4 or less members (AOR=1.093, 95% CI: 1.034-1.155), lower standard of living compared with the high standard of living (AOR=1.203, 95% CI: 1.084-1.334) and the medium standard of living compared with the high standard of living (AOR=1.090, 95% CI: 1.004-1.184) were showed significant association with the prevalence of the anemia.

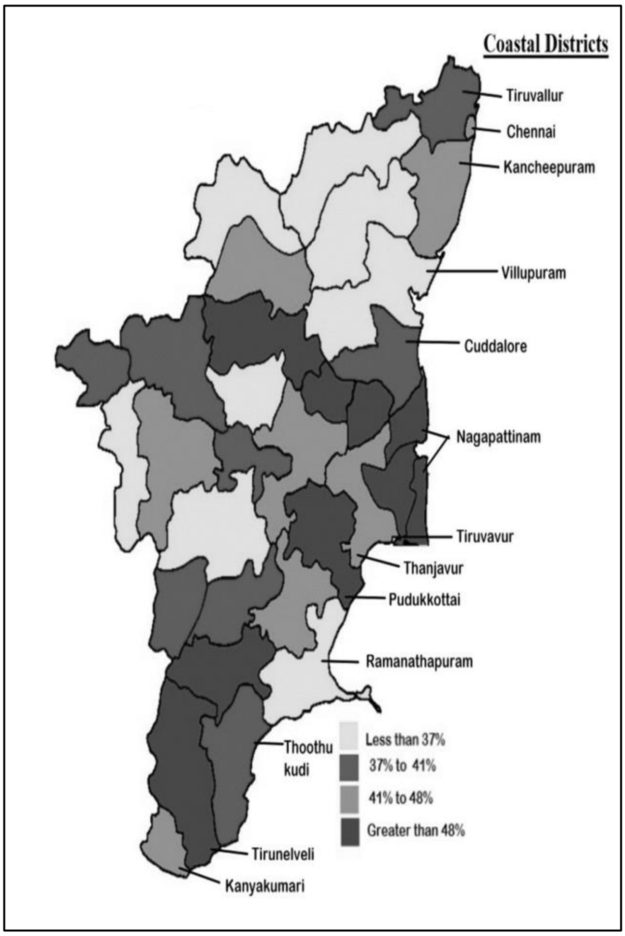

Figure 1: Distribution of anemia across the districts of Tamil Nadu.

In our study, we have considered the cut off value for anemia as less than 11 g/dL hemoglobin in blood.[8,16] However, in some recent studies, the cut off value for anemia for the age group 6-11 years was recommended as less than 11.5 g/dL hemoglobin and for the 12-17 years age group as less than 12 g/dL hemoglobin in blood.[17] Accordingly when we re-estimated the weighted prevalence, it was more alarming to note that the prevalence of anemia among school going children of age 6-11 years was 59.7% (95% CI: 56.89-62.501) and for school going children of age 12-17 years was 62.1% (95% CI: 61.23-62.96).

Table 1: Background characteristics of study participants by anemia (n=23997).

Variables	Anemia status										Total	P value	Weighted prevalence (95% CI*)
	Non-anemic		Mild		Moderate		Severe		Any anemia				
	N	%	N	%	N	%	N	%	N	%			
Age (in years)													
6 - 10	5336	54.2	2323	23.6	2026	20.6	167	1.7	4516	45.8	9852	<0.001	45.6 (44.6, 46.6)
11 - 17	8675	61.3	2696	19.1	2537	17.9	237	1.7	5470	38.7	14145		38.5 (37.7, 39.3)
Gender													
Male	7637	62.9	2270	18.7	2069	17	175	1.4	4514	37.1	12151	<0.001	36.9 (36.03, 37.7)
Female	6374	53.8	2749	23.2	2494	21.1	229	1.9	5472	46.2	11846		46.1 (45.2, 47.0008)
BMI (kg/m^2)													
Below 18.5	3044	61.3	920	18.5	929	18.7	69	1.4	1918	38.7	4962	<0.001	38.4 (37.05, 39.75)
18.5-24.9	10427	57.5	3915	21.6	3478	19.2	320	1.8	7713	42.5	18140		42.4 (41.68, 43.12)
25-29.9	371	62	118	19.7	99	16.6	10	1.7	227	38	598		37.7 (33.82, 41.58)
30 and above	169	56.9	66	22.2	57	19.2	5	1.7	128	43.1	297		43.2 (37.56, 48.84)
Family members													
4 or less	6579	60.1	2196	20.1	1979	18.1	186	1.7	4361	39.9	10940	<0.001	39.7 (38.78, 40.62)
5-7	6434	57	2420	21.4	2250	19.9	187	1.7	4857	43	11291		42.9 (41.98, 43.82)
8 or more	998	56.5	403	22.8	334	18.9	31	1.8	768	43.5	1766		43.2 (40.88, 45.52)
Household ownership													
Owned	11174	58.2	4010	20.9	3669	19.1	342	1.8	8021	41.8	19195	0.319	41.6 (40.9, 42.3)
Rented	2733	58.9	990	21.4	854	18.4	60	1.3	1904	41.1	4637		40.9 (39.5, 42.3)
Others	104	63	19	11.5	40	24.2	2	1.2	61	37	165		35.9 (28.62, 43.18)
Sanitation facilities													
Un-improved	6860	56.4	2591	21.3	2485	20.4	220	1.8	5296	43.6	12156	<0.001	43.4 (42.51, 44.29)
Improved	7151	60.4	2428	20.5	2078	17.5	184	1.6	4690	39.6	11841		39.5 (38.62, 40.38)
Drinking water source													
Un-improved	681	60.5	248	22	182	16.2	14	1.2	444	39.5	1125	0.135	39 (36.14, 41.86)
Improved	13330	58.3	4771	20.9	4381	19.2	390	1.7	9542	41.7	22872		41.6 (40.96, 42.24)
Type of locality													
Rural	7645	57	2839	21.2	2699	20.1	234	1.7	5772	43	13417	<0.001	42.9 (42.05, 43.75)
Urban	6366	60.2	2180	20.6	1864	17.6	170	1.6	4214	39.8	10580		39.7 (38.78, 40.62)
Standard of living (SLI)													
Low	3838	55.3	1507	21.7	1448	20.9	148	2.1	3103	44.7	6941	<0.001	44.5 (43.32, 45.68)
Medium	7963	59	2781	20.6	2529	18.8	213	1.6	5523	41	13486		40.8 (39.97, 41.63)
High	2210	61.9	731	20.5	586	16.4	43	1.2	1360	38.1	3570		37.9 (36.31, 39.49)
Total	14011	58.4	5019	20.9	4563	19	404	1.7	9986	41.6	23997	---	41.4 (40.77, 42.02)

Table 2: District level variation on the prevalence of anemia.

District	Anemia status				Total	Weighted prevalence (95% CI*)
	Non-anemic		Anemic			
	N	%	N	%		
Thiruvallur	491	60	328	40	819	39.6 (36.23, 42.97)
Chennai	415	58.5	295	41.5	710	42.4 (38.82, 45.97)
Kancheepuram	415	55.8	329	44.2	744	44.1 (40.53, 47.67)
Vellore	740	65.3	393	34.7	1133	34.6 (31.81, 37.39)
Tiruvannamalai	801	67.4	388	32.6	1189	31.8 (29.14, 34.46)
Viluppuram	483	63.6	276	36.4	759	36.6 (33.15, 40.05)
Salem	400	49	417	51	817	50.7 (47.27, 54.13)
Namakkal	600	68	282	32	882	31.8 (28.72, 34.88)
Erode	511	61.6	318	38.4	829	38.2 (34.86, 41.53)
The Nilgiris	386	61.6	241	38.4	627	39 (35.19, 42.81)
Dindigul	431	71.1	175	28.9	606	29 (25.39, 32.61)
Karur	423	62.9	250	37.1	673	37.5 (33.83, 41.17)
Tiruchirappalli	312	55	252	45	567	43.9 (39.82, 47.98)
Perambalur	340	47.2	380	52.8	720	52.6 (48.95, 56.25)
Ariyalur	247	43.7	318	56.3	565	55.7 (51.55, 59.85)
Cuddalore	455	61	291	39	746	38.8 (35.32, 42.28)
Nagapattinam	172	44.8	212	55.2	384	56.1 (51.16, 61.04)
Thiruvarur	319	43.6	413	56.4	732	55.6 (51.97, 59.23)
Thanjavur	414	56.6	318	43.4	732	43.8 (40.18, 47.42)
Padukkottai	393	51.5	370	48.5	763	48.8 (45.17, 52.43)
Sivaganga	368	52.1	338	47.9	706	47.3 (43.59, 51.01)
Madurai	439	61.6	274	38.4	713	38.2 (34.63, 41.77)
Theni	567	58.6	401	41.4	968	40.7 (37.59, 43.81)
Virudhunagar	233	47.2	261	52.8	494	52.9 (48.46, 57.34)
Ramanathapuram	440	66.8	219	33.2	659	32.7 (29.12, 36.28)
Thoothukkudi	436	59.6	296	40.4	732	40.4 (36.85, 43.95)
Tirunelveli	457	51.7	427	48.3	884	48.3 (45, 51.6)
Kanyakumari	382	52.8	341	47.2	723	46.8 (43.14, 50.46)
Dharmapuri	373	55.6	298	44.4	671	44 (40.22, 47.78)
Krishnagiri	455	68.9	205	31.1	660	31.3 (27.76, 34.84)
Coimbatore	785	67.3	381	32.7	1166	32.8 (30.09, 35.51)
Tiruppur	328	52.6	296	47.4	624	46.9 (42.98, 50.82)

Chi-square=556.374 and p<0.001. CI*: Confidence Interval.

Table 3: Parameter estimates of two-level empty model with intra class correlation coefficient (ICC).

Covariates	Estimate	Adjusted odds ratio	P value
Fixed effect			
Intercept	-0.315	0.730	<0.001
Random effect			
Var (intercept)	0.1	---	<0.001
ICC=0.1/(0.1+3.289)=0.0295			

Table 4: Distribution of weighted prevalence of anemia across the districts of Tamil Nadu.

Variables	Districts	No. of districts in coastal area
>37%	Coimbatore, Dindigul, Krishnagiri, Namakkal, Ramanathapuram, Tiruvanmalai, Vellore, Vilippuram	2
37-41%	Cuddalore, Erode, Karur, Madurai, The Nilgris, Theni, Thiruvallur, Thoothukkudi,	3
41-48%	Chennai, Dharmapuri, Kancheepuram, Kanniyakumari, Sivaganga, Thanjavur, Tiruchirapalli, Tiruppur,	4
<48%	Ariyalur, Nagapattinam, Padukkottai, Perambalur, Salem, Thiruvarur, Tirunelveli, Virudhunagar	4

Table 5: Comparison of prevalence of anemia, SLI and BMI across coastal and non-coastal areas.

Variables	Coastal districts, (n=13)	Non-coastal districts (n=19)	P value
Prevalence of anemia (%)	43.8	40.18	<0.001
	Mean (SD)	**Mean (SD)**	
SLI	18.34 (5.89528)	18.29 (5.62084)	0.423
BMI (Kg/m^2)	17.77 (30.33130)	17.64 (37.61915)	0.782

Table 6: Odds ratios with fixed and random effects of selected covariates obtained from two-level random intercept logistic regression model.

Covariates	Estimate	Adjusted odds ratio (95% CI*)	P value
Fixed effects			
Intercept	-0.954	0.385 (0.314,0.472)	<0.001
Age category (11-17 age group is set as reference group) (In years)			
6-10	0.295	1.343 (1.270,1.420)	<0.001
Gender (Male is set as the reference category)			
Female	0.380	1.462 (1.387,1.541)	0.001
BMI (18.5-24.9 is set as the reference category) (Kg/m^2)			
Below 18.5	0.063	1.065 (0.994,1.141)	0.072
25-29.9	-0.013	0.987 (0.826,1.180)	0.889
30 and above	0.107	1.113 (0.876,1.413)	0.382
Family members (4 or less is set as the reference category)			
5-7	0.089	1.093 (1.034,1.155)	0.002
8 or more	0.114	1.120 (1.008,1.245)	0.035
Household ownership (owned is set as the reference category)			
Rented	0.006	1.006 (0.934,1.083)	0.878
Other	-0.186	0.831 (0.599,1.152)	0.267
Sanitation facilities (Unimproved is set as the reference category)			
Improved	-0.016	0.984 (0.916,1.058)	0.664
Drinking water source (Unimproved is set as the reference category)			
Improved	0.082	1.086 (0.958,1.231)	0.199
Type of locality (Urban is set as reference category)			
Rural	0.098	1.103 (1.038,1.172)	0.002
Standard of living (High is set as the reference category)			
Medium	0.087	1.090 (1.004,1.184)	0.040
Low	0.185	1.203 (1.084,1.334)	<0.001
Random effect			
Var (intercept)	0.099	---	<0.001

DISCUSSION

The present study comprehensively indicates that half of the school going children are anemic in the state. Prevalence of anemia among school going children showed a district level variation and was more significantly associated with districts in the coastal areas. Besides, we were not able to observe much differences neither in BMI nor in standard of living between those residing in coastal districts and non-coastal districts.

Many studies reported that hookworm infection is among major causes of anemia particularly among people residing in coastal areas.[18,19] Also reported that hookworm infection increases risk of anemia and causes negative effects on growth, iron status and cognition in children with high intensity infections.[20] However, there are no sufficient data to quantify benefits of deworming as prevention of anemia and further studies are warranted.

Children of age 6-10 years more affected with anemia compared to children of age 11-17 years and supports findings of Zelalem et al. However, our findings do not support evidence that absorbed iron requirements increases with age, compared to other energy requirements in children.[16]

In our study, prevalence of anemia was higher among female children compared to male children. One of the reasons may be menstrual blood loss. In some studies, it was reported that menstrual losses range from 10-250 mL (4-100 mg of iron) per period.[21] These iron losses in female children double their need to absorb iron in comparison to male children.

In our study it was observed that the prevalence of anemia was higher among children residing in family with eight or more members compared to four or less than it. This could be due to the competition for food, nutritional deficiencies and other related factors. This finding is supported by similar studies.[22]

In our study the prevalence of anemia was higher in rural areas and those having lower standard of living. This could be due to the fact that those who have high standard of living are more likely to provide balanced macro and micro nutrients to their children and children from these families have more chance of accessing health care services. Besides, poor sanitation and worm infestation can also contribute to their higher prevalence. Our results, with the support of other studies confirm that children from lower standard of living are vulnerable to various nutritional disorders including anemia.[23]

CONCLUSION

The potential strength of our study is the use of all available data (DLHS-4) for the state of Tamil Nadu which enabled us to have a larger sample size. In addition, the use of two-level logistic regression analysis helped us to observe the district level variation of the data and to have a better insight to locate the high and low hotspot areas of anemia in the state. Limitations of the study include the cross-sectional nature of the study and therefore the temporal relationship between anemia and explanatory factors can not be established. Other confounders like presence of fever and diarrhoea were not included in the analysis. Nevertheless, these biases are non-differential as they are independent of the characteristics of children. In conclusion, we observed that half of the school going children were anemic in the state. The prevalence of anemia was significantly higher among coastal districts. It was also observed that it was more prevalent in the younger ages and those residing in lower standard of living. Therefore, the interventions of government and regional health centres should consider these factors also to avert the consequences of anemia in school going children.

ACKNOWLEDGEMENTS

Author would like to thanks to Dr. Tadury Madhukar Subbarao, Principal, PSG Institute of medical sciences and research, for permitting us to do this study. We express our gratitude to Dr. Sudha Ramalingam, director of research and innovation, HOD, department of community medicine, PSG institute of medical sciences and research, for permitting and providing the necessary support and facilities for doing this study. We also express our gratitude to Dr. M Sivamani, professor community medicine for his valuable suggestions in improving the quality of the paper. We are also indebted to Dr. S. L. Ravishankar, professor, department of community medicine, PSG institute of medical sciences and research, for his valuable guidance.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Mathew AC, Mathew SPR, Nair KS, Priya KK, Ramesh S. Prevalence and determinants of anemia among school going children in the state of Tamil Nadu, India: applications of two-level logistic regression model. Int J Community Med Public Health 2023;10:4743-50.