ORIGINAL RESEARCH ARTICLE

Prevalence And Determinants of Anemia Among Adolescents in Coimbatore District, Tamil Nadu – A School Based Analytical Cross-Sectional Study

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ABSTRACT

Context: The objective of the study was to estimate the prevalence of anemia among adolescents 10 to 19 years of age disaggregated by age group and gender. We also assessed the determinants of anemia among adolescents.

Methods: An analytical cross-sectional study was carried out between July and November 2019 in a senior secondary public school, located in Coimbatore district, Tamil Nadu, India using a predesigned, semi-structured, pretested proforma that included haemoglobin estimation using oxyhemoglobin method.

Results: The overall prevalence of anemia was 88.6% (95% CI 87.2 to 89.8); it was ten percent points higher in females (93.8%, 95% CI 92.1 to 95.1) compared to males (83.9%, 95% CI 81.7 to 85.8). Multivariate regression analysis showed that early adolescents (AOR 3.05, 95% CI 2.19 to 4.24), females (AOR 6.94, 95% CI 4.90 to 9.83), those with A or B or AB blood groups (AOR 2.58, 95% CI 1.92 to 3.49), physical inactivity (AOR 2.18, 95% CI 1.43 to 3.33) and attainment of menarche (AOR 2.69, 95% CI 1.73 to 4.21) were independent predictors of anemia in adolescents.

Conclusion: It is the need of the hour to identify vulnerable groups; factors that predict occurrence, prioritize them to design and implement an effective public health action. Also, the effectiveness of existing strategies in the form of periodic deworming, Iron and Folic acid tablets (IFA) should be reassessed.

Key words: Adolescence, anemia, prevalence, predictors, India

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INTRODUCTION

Adolescence refers to 10–19 years of age; period between under five children and adults is growing more distinct as the health status during childhood and adolescence is the foundation for future health and wellbeing or mortality and morbidity risks.[1,2] It has been estimated that adolescents constitute 16% of global population.[3] Importantly, more than half of all adolescents live in Asia, especially South Asia. Of the 350 million adolescents from South Asia, 69.4% are from India. Adolescents constitute 21% of the Indian population.[3-5] They represent the potential influencers of future economic growth and development and this period between 10 to 19 years of life is the ground for investment and provides a window of opportunity for laying a solid foundation to a brighter and healthier future.

Anemia is a public health problem of high magnitude in India (prevalence more than 40.0%). The latest estimates from National Family Health Survey (NFHS-5) shows that the prevalence of anemia among adolescent girls and boys 15 to 19 years 59.1% and 31.1% respectively.[6] The prevalence of severe anemia among them was 2.6% and 0.3% respectively.[6] Anemia is an indicator of both poor health and nutrition.[7] It compromises physical development thereby reducing work capacity and productivity;[8] impairs sexual and reproductive development resulting in irregular menstruation, low pre-pregnancy iron stores and poor pregnancy outcomes including preterm and/or low birthweight deliveries;[9,10] and reduces cognitive development resulting in diminished concentration, disturbance in perception and poor learning ability.[11,12] Overall, anemia affects quality of life contributing to high health-care costs. Literature evidence highlights that presence of anemia attributes to 5.25 days lost per person lifetime.[13] Cost effectiveness calculations reveal that it can cost approximately $75.97 (5063.47 INR) for each DALY lost due to iron deficiency anemia.[13] In a recent analysis of social costs of iron deficiency anemia – intangible costs were 8.3 million DALYs and production losses were 24,001 million USD; accounting for 1.3% of gross domestic product.[14] Adolescence as a stage of life and presence or absence of anemia in adolescence is important to estimate and understand because of its role in intergenerational impact.

The Comprehensive National Nutrition Survey (CNNS, 2016-18) documented the prevalence of anemia among adolescents 10 to 19 years of age to be 16.4%.[15] However, disaggregated data on prevalence of anemia by age group (early and late adolescence) and gender were not explicitly provided. Such disaggregated data in combination with risk factors of greater attributable risk may aid in identifying vulnerable pockets of adolescents to anemia and to plan most effective, appropriate, accessible, and culturally acceptable public health action. Against this background, the objective of the study was to estimate the prevalence of anemia among adolescents 10 to 19 years of age disaggregated by age group and gender. We also assessed the determinants of anemia among adolescents.

SUBJECTS AND METHODS

An analytical cross-sectional study was carried out between July and November 2019 in a senior secondary public school, located in Coimbatore district, Tamil Nadu, India.

It has been documented that the prevalence of anemia among Indian adolescent (15 to 19 years of age) girls and boys were 54.0% and 29.0% respectively.[16] We computed sample size using 54.0% prevalence, 5.0% relative precision and 95% confidence interval (CI). As the study participants were selected from only one school and not from all schools in Coimbatore district, Tamil Nadu – to account for the variation in probability at which participants are selected, we used design effect of 1.5. Finally, the minimum sample size was estimated to be 1963.

We conducted complete enumeration of all adolescents (10 to 19 years of age) present on the day of survey to include a sample of 2263 adolescents. The school was visited twice; on day 1, permission was sought from school principal, explanation of the study was given, and consent/assent forms were handed out to all eligible students. On day 2 the predesigned, semi-structured, pretested proforma that included sociodemographic factors and risk factor assessment for anemia was administered by face-to-face interview method. This was followed by anthropometric assessment (weight and height) and estimation of haemoglobin (g/dl). The study participants were then organized in groups and given health education (based on predesigned module) in the local language (Tamil) through an interactive talk. Health education was focused primarily on risk of anemia and other nutrition deficiency disorders; ways to prevent and manage the same. Deworming tablets were provided to every study participant following the session.

Measurement of weight (to the accuracy of 100 gm) and height (0.1 mm) was done using standardized, calibrated weighing machine and stadiometer. Body Mass Index (BMI) was calculated using Quetelet index (kg/m2) and was categorized using WHO Child Growth Standards into thinness grades ("zbmicat" command in Stata v16 was used).[17] Hemoglobin estimation was done using oxyhemoglobin method.[18] The collected samples were labelled with unique participant ID and brought to a National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory in cold boxes (at 2-8^{o} C) within the appropriate time period. Upon receipt of hemoglobin reports, if the adolescent is anemic [hemoglobin levels < 8.0 g/dl (severe anemia) or ≥ 8.0 to < 11 g/dl (moderate anemia) or ≥ 11 g/dl to < 12 g/dl (mild anemia)], the participant ID was un-

blinded and reports shared with the school principal.[19] External quality checks were performed for the laboratory to ensure the reliability and accuracy of the results. This was done by sending a proportion of all samples in duplicate to another lab or unknown duplicates to the same lab.

Data collected was entered in Microsoft Excel and analysed using Stata v16. The data was described using numbers, percentages and presented in tables. Chi square test of significance (two-sided) for categorical and independent or unpaired t tests for continuous outcomes was applied to test for association between presence or absence of anemia in adolescents or absolute levels of haemoglobin and independent variables. Univariate odds ratio was estimated along with 95% CI for these variables. Variables significant at $p<0.05$ in univariate analysis were included in multivariate logistic regression analysis. Adjusted odds ratios (95% CI) were presented. We used to direct acyclic graph (DAG) to identify that set of factors to be adjusted for to compute the total effect of predictors on anemia in adolescents.[20] The study was approved by Institute Ethical Committee (IEC), Karpagam Faculty of Medical Sciences & Research, Coimbatore (IHEC/47/Community Medicine/03/2016). The approval was also obtained from the head of department, school principal and teachers. Consent or assent from parents and students were obtained a prior.

RESULTS

The mean (SD) age of the study population was 14.1 (1.9). More than half, 1265 (55.9%) participants were less than or equal to 14 years of age; 1190 (52.6%) participants were males (Table 1). Two thirds, 1506 (66.5) participants were from a family of less than or equal to four. The mean (SD) family size was 4.4 (0.9). Based on WHO Growth Standards, one third (32.1%) of participants were thin, 10.7% participants were either overweight or obese and 57.3% were normal. The most common blood group among the study participants was 'O' (39.6%) followed by 'B' (34.1); and majority (93.4%) were Rh positive. The mean (SD) height (cm), weight (kg) and BMI (kg/m^2) were 151.7 (9.1), 43.5 (10.9) and 18.7 (3.8) respectively.

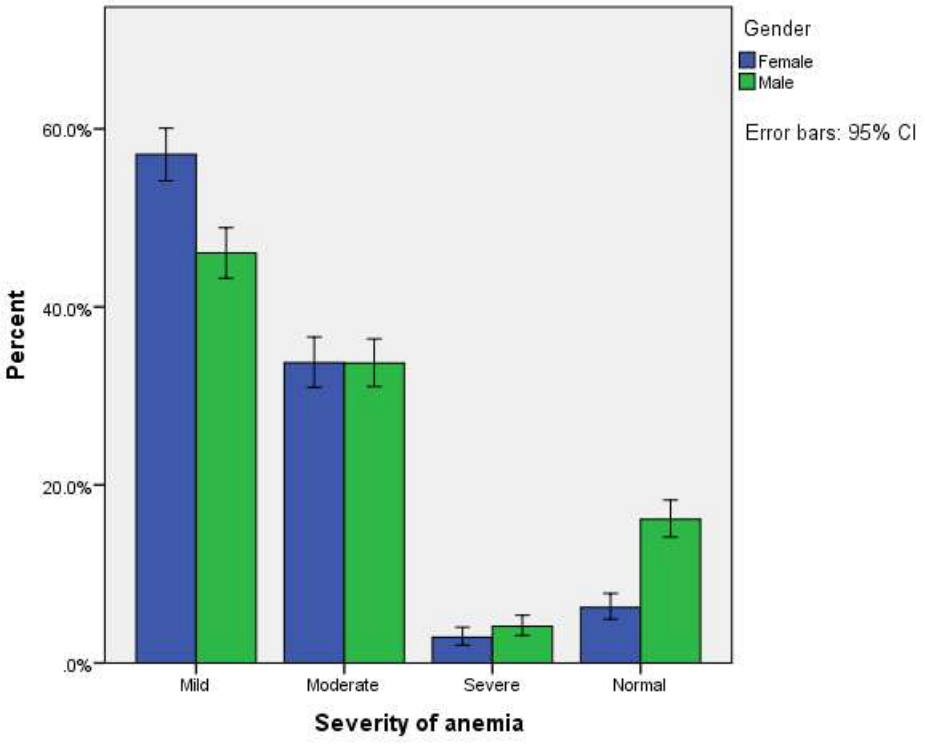

Figure 1: Prevalence of anaemia, by severity and gender

Prevalence of anemia: The overall prevalence of anemia in the present study was 88.6% (95% CI 87.2 to 89.8); it was ten percent points higher in females (93.8%, 95% CI 92.1 to 95.1) compared to males (83.9%, 95% CI 81.7 to 85.8). Based on severity, the prevalence of mild, moderate, and severe anemia was 51.3% (95% CI 49.2 to 53.4), 33.7 (31.8 to 35.7) and 3.5% (2.8 to 4.4) (Figure 1). The mean (SD) hemoglobin (g/dl) in the present study was 10.0 (1.5).

Determinants of anemia in adolescents: In univariate analysis, we found that participants 10 to 14 years of age were at 1.94 (95% CI 1.50 to 2.53) times increased risk of anemia in comparison to those between 15 and 19 years of age. The levels of hemoglobin among early adolescents were significantly lower than that of late adolescents (MD -0.41, 95% CI -0.53 to -0.29).

Table 1: Distribution of study variables (N = 2263)

Variables	Participants (%)
Age*	
Early adolescence	1265 (55.9)
Late adolescence	998 (44.1)
Gender	
Female	1073 (47.4)
Male	1190 (52.6)
Family size	
≤4	1506 (66.5)
≥5	757 (33.5)
Body mass index^	
Grade 3 thinness	160 (7.1)
Grade 2 thinness	169 (7.5)
Grade 1 thinness	397 (17.5)
Normal	1296 (57.3)
Overweight	203 (9.0)
Obese	38 (1.7)
Blood group (n = 2235)	
A	450 (20.1)
B	763 (34.1)
AB	136 (6.1)
O	886 (39.6)
Rh status (n = 2247)	
Positive	2099 (93.4)
Negative	148 (6.5)
Intake of nutrient enriched drinks	
≥3 times/week	838 (37.0)
<3 times/week	513 (22.7)
No	912 (40.3)
Type of diet	
Vegetarian	150 (6.6)
Non vegetarian	2113 (93.4)
Frequency of having non vegetarian food (n = 2113)	
> Once per week	96 (4.5)
≤ Once per week	2017 (95.5)
Physical activity&	
Present	325 (14.4)
Absent	1938 (85.6)
Menarche	
Attained	1659 (73.3)
Not attained	604 (26.7)

*Early adolescence, between 10 and 14 years of age; Late adolescence, between 15 and 19 years of age

^Grade 3 thinness, BMI <16 kg/m2; Grade 2 thinness, BMI between 16 and <17; Grade 1 thinness, BMI between 17 and <18.5; Normal weight, BMI between 18.5 and <25; Overweight, BMI between 25 and <30; Obese, BMI more than 30

&Physical activity present, moderate-to-vigorous intensity, mostly aerobic physical activity, at least an average of 60 minutes per day, across the week (or) vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, at least 3 days a week; Physical activity absent, those that do not satisfy the above criteria

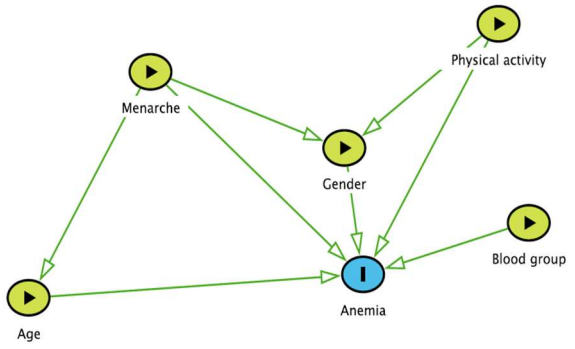

Figure 2: Directed acyclic graphs showing interaction of independent variables on anemia

We also found a statistically significant association between female gender (OR 2.89, 95% CI 2.16 to 3.87), A or B or AB blood groups (OR 1.41, 95% CI 1.08 to 1.83), physical inactivity (OR 1.62, 95% CI 1.11 to 2.37), attainment of menarche (OR 2.83, 95% CI 1.93 to 4.15) and anemia in adolescents (Table 2). However, when levels of hemoglobin considered in a continuous scale, statistical significance was retained only for early adolescence (MD -0.41, 95% CI -0.53 to -0.29) and attainment of menarche (MD -0.48, 95% CI -0.62 to -0.35) (Table 3).

The variables that require adjustment for multivariate regression analysis were explored using directed acyclic graphs. However, the results showed that no adjustment is necessary to estimate the total effect of age, gender, blood group, physical activity, and attainment of menarche on anemia in adolescents. Multivariate regression analysis showed that early adolescents (AOR 3.05, 95%CI 2.19-4.24), females (AOR 6.94, 95%CI 4.90-9.83), those with A or B or AB blood groups (AOR 2.58, 95%CI 1.92-3.49), physical inactivity (AOR 2.18, 95%CI 1.43-3.33) and attainment of menarche (AOR 2.69, 95%CI 1.73-4.21) were independent predictors of anemia in adolescents.

Discussion

In the present study most, adolescents had anemia; more than half (51.3%) had mild and 3.5% had severe anemia. This is much higher than the estimates provided by National Family Health surveys 4 and 5 and CNNS (2016-18).[6,15,16] Studies conducted in Tamil Nadu found the prevalence of anemia among adolescents to range between 48.0% and 79.0%.[21-23] The higher prevalence in the present study may be attributed to the lower socioeconomic background, related poor nutrition and insanitary environment. However, two important points emerge. Firstly, similar to the findings of this study, there may be other pockets in India where the prevalence of anemia is higher than that reported at state or national level. Secondly, the cutoffs used for categorizing participants with anemia may be higher for India resulting in majority being labeled anemic.[24] A population-based study used age-specific and sex-specific 5th percentiles of hemoglobin derived from a healthy population as the study cutoff to define anemia, compared it with existing WHO cutoffs.[25] It was found that the study cutoffs for hemoglobin were lower at all ages, usually by 1–2 g/dL, but more so in girls aged 10 years or older. The prevalence of anemia with the study cutoffs were 19.2% lower than with WHO cutoffs in the entire CNNS sample with valid hemoglobin values across all ages and sexes.[25]

Soil transmitted helminthic infections and/or presence of ova or cyst in stool is a known risk factor of anemia (OR 4.15, 95% CI 1.18 to 14.59).[26] A recently published study documented the prevalence of soil transmitted helminthic (STH) infections in the study area to be 7.7% (95% CI 5.6 to 9.8).[27]

Table 2: Univariate and multivariate logistic regression analysis showing association between independent variables and presence or absence of anemia

Variables	Anemia		Total (%)	OR (95% CI)	AOR (95% CI)
	Present (%) (N = 2004)	Absent (%) (N = 259)			
Age					
Early adolescence	1158 (57.8)	107 (41.3)	1265 (55.9)	1.94 (1.50 to 2.53)	3.05 (2.19 to 4.24)
Late adolescence	846 (42.2)	152 (58.7)	998 (44.1)	1	1
Gender					
Female	1006 (50.2)	67 (25.9)	1073 (47.4)	2.89 (2.16 to 3.87)	6.94 (4.90 to 9.83)
Male	998 (49.8)	192 (74.1)	1190 (52.6)	1	1
Family size					
≤4	1335 (66.6)	171 (66.0)	1506 (66.5)	1.03 (0.78 to 1.35)	_
≥5	669 (33.4)	88 (34.0)	757 (33.5)	1	
Body mass index					
Thinness	639 (31.9)	87 (33.6)	726 (32.1)	0.92 (0.69 to 1.22)	_
Overweight/obese	213 (10.6)	28 (10.8)	241 (10.6)	0.95 (0.62 to 1.46)	
Normal	1152 (57.5)	144 (55.6)	1296 (57.3)	1	
Blood group					
A or B or AB	1215 (61.3)	134 (53.0)	1349 (60.4)	1.41 (1.08 to 1.83)	2.58 (1.92 to 3.49)
O	767 (38.7)	119 (47.0)	886 (39.6)	1	1
Rh status					
Positive	1864 (93.6)	235 (92.2)	2099 (93.4)	1.24 (0.76 to 2.02)	_
Negative	128 (6.4)	20 (7.8)	148 (6.6)	1	
Intake of nutrient enriched drinks					
≥3 times/week	751 (37.5)	87 (33.6)	838 (37.0)	1.18 (0.88 to 1.60)	_
≤3 times/week	451 (22.5)	62 (23.9)	513 (22.7)	0.99 (0.72 to 1.39)	
No	802 (40.0)	110 (42.5)	912 (40.3)	1	
Type of diet					
Vegetarian	132 (6.6)	18 (6.9)	150 (6.6)	0.94 (0.57 to 1.57)	_
Non vegetarian	1872 (93.4)	241 (93.1)	2113 (93.4)	1	
Frequency of having non vegetarian food (n = 2113)					
> Once per week	81 (4.3)	15 (6.2)	96 (4.5)	1	_
≤ Once per week	1791 (95.7)	226 (93.8)	2017 (95.5)	1.47 (0.83 to 2.59)	
Physical activity					
Absent	1817 (90.7)	222 (85.7)	2039 (90.1)	1.62 (1.11 to 2.37)	2.18 (1.43 to 3.33)
Present	187 (9.3)	37 (14.3)	224 (9.9)	1	1
Menarche					
Attained	572 (28.5)	32 (12.4)	604 (26.7)	2.83 (1.93 to 4.15)	2.69 (1.73 to 4.21)
Not attained	1432 (71.5)	227 (87.6)	1659 (73.3)	1	1

A systematic review published from a similar other developing nation showed the overall pooled estimate of STH infections to be 33.0% (95% CI 28.0 to 38.0%).[28] The studies underline the importance of limiting STH infections to prevent anemia and role of mass drug administration with Albendazole or Mebendazole at least once yearly. However, in India, the existing policy recommends biannual deworming (fixed National Deworming Day approach, preferably February 10 and August 10) for all between one and 19 years of age with Albendazole tablets.[29]

The present study found that early adolescents, females, those with A or B or AB blood groups, physical inactivity and attainment of menarche were independent predictors of anemia between 10 and 19 years of age. Females, 10 to 14 years of age and attainment of menarche – early adolescence or preadolescence or pubertal phase – emphasizes the increase in iron demand due to growth and menstruation.[30] 'The Healthy Growth study' documented that the total daily iron requirements in girls almost double during adolescence.[31] They increased from a range of 1.22 to 1.46 mg/day before menarche to a range of 1.39 to 2.54 mg/day after menarche. The rise in total blood volume and lean body mass in children entering adolescence and menstrual iron losses in girls are the possible explanations.[31]

Literature evidence shows that individuals with A or B or AB blood groups are relatively prone to anemia in comparison to O blood group.[32] In a study conducted to determine the association between blood phenotype and anemia it was found that the prevalence of anemia was significantly higher among participants with AB blood group ($p = 0.001$).[33] However, similar to the findings of this study Rhesus (D) antigen was not significantly associated with anemia. The findings of this study corroborate with that of the existing evidence; shows that physical activity of any form, particularly jogging and aerobic exercise significantly increased hemoglobin levels.[34-36] In a study that investigated the association of physical activity (International Physical Activity Questionnaire (IPAQ)) and hemoglobin concentration it was found that the mean hemoglobin concentrations were 14.8 g/dL, 15.2 g/dL and 15.6 g/dL in low, moderate, and high physical activity respectively.[34]

Table 3: Univariate analysis showing association between independent variables and mean (SD) hemoglobin levels

Variables	Mean (SD)	MD (95% CI)
Age		
Early adolescence	9.80 (1.44)	-0.41 (-0.53 to -0.29)
Late adolescence	10.21 (1.45)	1
Gender		
Female	9.94 (1.33)	-0.09 (-0.21 to 0.03)
Male	10.03 (1.57)	1
Family size		
≤4	9.95 (1.47)	-0.12 (-0.25 to 0.01)
≥5	10.07 (1.45)	1
Body mass index		
Thinness	9.94 (1.48)	-0.06 (-0.19 to 0.07)
Overweight/obese	10.02 (1.44)	0.02 (-0.19 to 0.22)
Normal	10.01 (1.46)	1
Blood group		
A or B or AB	9.95 (1.43)	-0.09 (-0.22 to 0.03)
O	10.04 (1.50)	1
Rh status		
Positive	9.98 (1.45)	-0.06 (-0.30 to 0.19)
Negative	10.04 (1.55)	1
Intake of nutrient enriched drinks		
≥3 times/week	9.99 (1.43)	0.03 (-0.11 to 0.16)
≤3 times/week	10.00 (1.52)	0.03 (-0.13 to 0.19)
No	9.97 (1.46)	1
Type of diet		
Vegetarian	9.89 (1.57)	-0.11 (-0.35 to 0.13)
Non vegetarian	9.99 (1.46)	1
Frequency of having non vegetarian food (n = 2113)		
> Once per week	10.09 (1.65)	1
≤ Once per week	9.99 (1.45)	-0.10 (-0.40 to 0.19)
Physical activity		
Absent	9.99 (1.44)	0.07 (-0.14 to 0.27)
Present	9.93 (1.67)	1
Menarche		
Attained	9.64 (1.42)	-0.48 (-0.62 to -0.35)
Not attained	10.12 (1.46)	1

In addition to the factors explored in this study, evidence highlights that there are protective factors against anemia that include (but not limited to) hand washing (especially after toileting and before food intake), regular use of footwear and consumption of jaggery.[26]

The present study is not without limitations. Firstly, the use of predefined categories for anemia classification may have overestimated the prevalence. Secondly, the factors included are limited and non-exhaustive. Also being a cross sectional study, the temporal association between independent variables and anemia could not be assessed. Thirdly, the study included adolescents from schools and there is a possibility of exclusion of out of school adolescents. However, the rates of school dropouts are very minimal in Tamil Nadu to substantially change the study findings.[37]

Conclusion

To conclude, the majority of adolescents 10 to 19 years of age had anemia. It is the need of the hour to identify vulnerable groups; factors that predict occurrence, prioritize them to design and implement an effective public health action. Also, the effectiveness of existing strategies in the form of periodic deworming, Iron and Folic acid tablets (IFA) should be reassessed.

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