

# Burden of anemia and its socioeconomic determinants among adolescent girls in India

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## Abstract

**Background.** Anemia is still one of India's major public health problems, especially among adolescent girls.

**Objective.** To investigate the severity and distribution of anemia among Indian adolescent girls aged 10 to 19 years and its association with socioeconomic and socio-demographic factors.

**Methods.** The study used data from the District Level Household Survey, round II, 2002–04, conducted under the Reproductive and Child Health Project. Data were collected on hemoglobin along with socioeconomic and sociodemographic factors of the households. The survey covered rural and urban areas of 35 states or union territories. Data from 177,670 adolescent girls were analyzed.

**Results.** The highest prevalence of anemia (99.9%) was observed in Jharkhand in eastern India. The prevalence in the northeastern states was relatively low. The highest prevalence rates were observed among older girls (15 to 19 years), illiterate girls living in rural areas, girls in illiterate households, girls from households with a low standard of living, non-Christian girls, girls from Scheduled Tribes, girls living in west India, and married girls. The highest percentages of girls with normal hemoglobin were reported among Christian Scheduled Tribes (39.4%) and among girls in northeastern India (40.1%). Analysis by binary ordered logistic regression showed that anemia status did not depend on urban or rural residence or on age.

**Conclusions.** Enhancement of the economic status of families, especially poor families, is a prerequisite to the amelioration of anemia among adolescent girls. The level of education of the girls is also a major factor.

**Key words:** Adolescent girls, anemia, India, socioeconomic factors

## Introduction

Anemia is still one of India's major public health problems [1], despite more than 37 years of iron and folic acid supplementation by the Government of India through the National Nutritional Anaemia Prophylaxis Programme (NNAP) launched in 1970. This program was started specifically for pregnant women. However, data on the prevalence of anemia during 1985 and 1986 were very discouraging [2]. Some modifications of NNAP have been done to make it more effective and efficient, but the basic problem still remains. This may be due to the fact that supplementation during pregnancy may be too late for desirable birth outcomes. A large number of women are already anemic to a great extent when they enter into pregnancy [3]. Therefore, iron and folic acid supplementation should be started prior to pregnancy or even earlier. In India, pregnancy generally occurs after marriage and the mean age of women at marriage is 18.3 years, which is in the adolescent (10 to 19 years) period [4]. Thus, it is essential to improve iron status in the adolescent period before childbearing, especially in developing countries such as India [5].

Deficient iron status or anemia among adolescent girls is a major cause of growth retardation [6–9], impaired physical and mental development [10], delayed menarche [11], morbidity [12], and future poor reproductive outcomes [13, 14]. Besides inadequate iron consumption, other major direct major causes of anemia are high menstrual blood loss [15], malaria [10], and hookworm infestation [16, 17]. In addition to these direct causes, there are indirect socioeconomic factors such as illiteracy, poverty, and rural residence that affect anemia [18].

Few microlevel studies have been conducted on the prevalence of anemia and its probable causes among Indian adolescent girls [19]. India is a large, multiethnic

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country, where the prevalence and determinants of anemia vary across regions and ethnic groups [20]. Data from the Reproductive and Child Health Project offer an opportunity to investigate the severity and distribution of anemia among adolescent girls aged 10 to 19 years at the national level, according to urban and rural areas, and according to state and region and to assess the trends and socioeconomic determinants of the prevalence of anemia.

## Materials and methods

### Data

The present paper uses the dataset of the District Level Household Survey (DLHS) under the Reproductive and Child Health (RCH) Project (round 2, 2002–04). Information was collected on various indicators pertaining to reproductive and child health, along with assessment of the levels of anemia among adolescent girls. Data are available on the hemoglobin levels and the socioeconomic and sociodemographic background of 177,670 girls aged 10 to 19 years.

In this study, we combined religion and caste into a single category to try to determine the effect of caste and religion when taken together. There are Hindus and Christians among the Scheduled Tribes. So it is necessary to take Hindu Scheduled Tribes and Christian Scheduled Tribes as separate groups to understand the interaction effect, if any (see Appendix). In 1935, the British passed the Government of India Act, which reserved job seats for the Depressed Classes. The Depressed Classes consist of Scheduled Castes and Scheduled Tribes only. According to the Indian Constitution of 1950, under the 'Articles 341 and 342', some castes and tribes are scheduled as the Scheduled Castes and Scheduled Tribes respectively to get the special benefits; namely, reserved places in the legislatures and jobs to bring these oppressed persons into the mainstream of society.

Measurements of hemoglobin levels of the girls were taken by trained investigators using the HemoCue system. This system uses a single drop of blood from a fingerprick, which is drawn into a cuvette and then is inserted into a portable, battery-operated instrument. In less than 1 minute, the hemoglobin concentration is displayed in the machine.

### Data analysis

Hemoglobin levels among the adolescent girls were classified on the basis of international standards [21] as normal ( $\geq 12.0$  g/dL), mild anemia (10.0 to 11.9 g/dL), moderate anemia (7.0 to 9.9 g/dL), and severe anemia ( $< 7.0$  g/dL). Thus, anemia is defined as a hemoglobin level less than 12.0 g/dL.

We analyzed socioeconomic and sociodemographic data, including place of residence (rural or urban), age, educational status of the adolescent girls, household standard of living index (SLI) (classified as low, medium, or high), religion and ethnicity, region of the country, and marital status (see the Appendix). The methods of data collection and their classification have been published in the DLHS-RCH report [20].

The prevalence of anemia among adolescent girls was analyzed for different zones that were obtained by combining 35 states or union territories. Anemia prevalence was also analyzed for different socioeconomic and sociodemographic groups of households. A chi-square test of contingency table was used to test for the significance of differences in anemia prevalence between these categories. To determine the association of anemia with the socioeconomic and sociodemographic variables, binary logistic regressions were carried out. For this analysis, the binary values taken by the dependent variable, anemia, were 1 for girls with moderate or severe anemia and 0 for others. We used SPSS, version 11.0, for analysis.

## Results

**Figure 1** shows the prevalence of anemia (hemoglobin  $< 12$  g/dL) among adolescent girls in 35 states or union territories. The highest prevalence (99.9%) was observed in Jharkhand, a newly formed state in eastern India. The mean hemoglobin level was 9.89 g/dL, and the prevalence of anemia was as high as 90%. The lowest mean hemoglobin level (8.3 g/dL) was observed in Chhattisgarh, a neighboring state of eastern India, which is also a newly formed state (not shown in **fig. 1**). Relatively low prevalence rates of anemia (as well as high mean hemoglobin levels) were observed in Meghalaya, Assam, Nagaland, Arunachal Pradesh, Manipur, and Mizoram states of northeast India. The lowest prevalence of anemia (31.6%) was reported in Manipur. High prevalence rates of anemia were also observed in developed states or union territories such as Delhi (92.3%), Hariyana (98.2%), Kerala, (85.7%) and Sikkim (76.2%). A total of 17 of 35 states or union territories had anemia prevalence rates of more than 90% among adolescent girls.

When the girls of different states and union territories are taken as a whole, the mean hemoglobin level is seen to decrease with increasing age (**table 1**). This trend is also reflected in the increasing prevalence of severe anemia (hemoglobin  $< 7$  g/dL) with increasing age. Girls 17 or 18 years of age have the highest prevalence of severe anemia (11.3%) and girls 10 years of age have the lowest (8.7%).

**Table 2** shows the prevalence of anemia with respect to different socioeconomic and sociodemographic variables. The prevalence of anemia is generally high,

and all of the variables are significantly ( $p < .001$ ) associated with anemia prevalence. The highest prevalence rates of severe anemia (hemoglobin  $< 7$  g/dL) were found among girls from rural areas (10.3%), girls 15 to 19 years of age (10.9%), illiterate girls (12.2%), girls from households with a low SLI (10.8%), girls from non-Christian Scheduled Tribes (13.6%), girls from west India (15.3%), and married girls (12.6%). The highest percentages of girls with normal hemoglobin levels were found in Christian Scheduled Tribes (39.4%) and in girls from northeast India (40.1%).

Binary ordered logistic regression (tables 3 and 4) was performed using different groups of explanatory variables as well as the response variable. The analyses were performed for both moderate-to-severe anemia (hemoglobin  $< 10$  g/dL) (table 3) and severe anemia (hemoglobin  $< 7$  g/dL) (table 4) as the dependent variable. Since the binary variable has a value of 1 for anemic girls, a positive value of the coefficient signifies a higher probability of being anemic as compared with the reference group. The results are presented as odds ratios (OR) with 95% confidence intervals (CI). In model 1 of table 3, girls from urban areas are observed to have significantly lower odds of being anemic (OR = 0.940; 95% CI, 0.919 to 0.960) than their rural counterparts. Similar results are observed after controlling for age group, marital status, and religion and caste in models

2 and 3. However, reverse results are observed after controlling for education and standard of living in model 4 and after controlling for education, standard of living and zone in model 5. In model 5, urban girls are

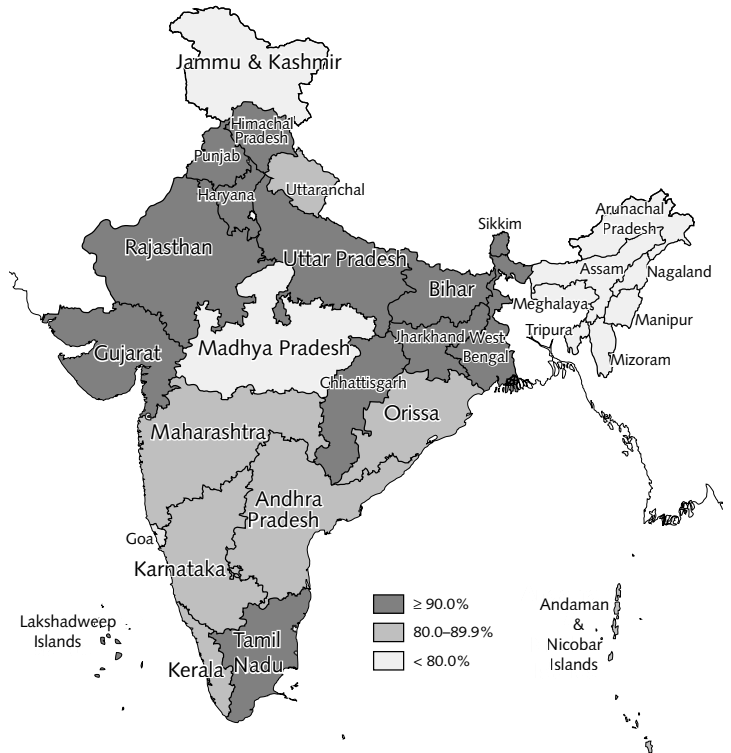


FIG. 1. Prevalence of anemia (mild, moderate, or severe, defined as hemoglobin  $< 12$  g/dL) among adolescent Indian girls according to state or union territory.

TABLE 1. Age-specific mean hemoglobin levels and prevalence of anemia among adolescent girls

Age (yr)	N	Hemoglobin (g/dL)		$\chi^2$	Prevalence (%) <sup>a</sup>				$\chi^2$
		Mean	SD		Severe anemia	Moderate anemia	Mild anemia	Normal	
10	23,152	9.98	3.87	4.635***	8.7	61.4	19.2	10.7	183.64***
11	15,549	9.99	3.86		8.9	60.7	19.8	10.6	
12	23,494	9.90	3.81		9.3	61.2	19.4	10.1	
13	17,747	9.92	3.89		9.9	60.5	19.1	10.5	
14	18,995	9.85	3.81		10.3	60.3	19.3	10.1	
15	18,977	9.83	3.82		10.7	60.1	19.0	10.2	
16	18,534	9.86	3.86		10.8	59.9	18.9	10.4	
17	14,189	9.87	3.80		10.5	59.2	20.1	10.2	
18	18,838	9.84	3.81		11.3	58.8	19.5	10.4	
19	8,195	9.79	3.76		11.3	59.6	18.4	10.7	
Total	177,6700	9.89	3.83		10.1	60.3	19.3	10.3	

a. Severe anemia is defined as a hemoglobin level  $< 7.0$  g/dL, moderate anemia as a hemoglobin level between 7.0 and 9.9 g/dL, and mild anemia as a hemoglobin level between 10.0 and 11.9 g/dL; hemoglobin levels  $\geq 12.0$  g/dL are considered normal.

\*\*\* $p < .001$  ( $\chi^2$  test of the contingency table of number of girls).

TABLE 2. Prevalence of anemia among adolescent girls with respect to different independent variables

Covariate <sup>a</sup>	N	Prevalence (%) <sup>b</sup>			
		Severe anemia	Moderate anemia	Mild anemia	Normal
Residence					
Rural	119,616	10.3	60.4	18.7	10.5
Urban	58,054	9.5	60.0	20.4	10.1
Age (yr)					
10–14	98,937	9.4	60.9	19.3	10.4
15–19	78,733	10.9	59.5	19.2	10.4
Educational level of adolescent girls					
Illiterate	30,249	12.2	61.5	15.4	10.8
Up to class IX*	122,372	9.7	60.4	19.6	10.3
X and above	25,049	9.3	58.4	22.2	10.1
SLI index					
Low	75,941	10.8	60.9	17.4	10.9
Medium	59,001	9.9	59.4	20.3	10.4
High	42,728	9.0	60.3	21.2	9.4
Religion and caste					
Muslim	22,932	9.0	56.3	23.2	11.5
Hindu (SC)	29,073	10.9	62.8	17.8	8.5
ST (non-Christian)	16,264	13.6	60.1	13.5	12.8
ST (Christian)	3,355	4.7	31.7	24.2	39.4
Other Hindus	97,049	9.6	61.4	19.7	9.3
Others	8,997	10.5	61.5	18.1	9.9
Zone					
Northeast	7,655	6.3	33.3	20.3	40.1
East	32,833	9.9	63.0	17.6	9.5
Central	48,944	10.3	62.3	16.6	10.8
West	21,459	15.3	62.8	13.7	8.2
North	42,057	9.5	64.5	19.6	6.4
South	23,867	7.6	52.4	29.9	10.0
Island	855	4.9	32.9	48.2	14.0
Marital status					
Married	12,125	12.6	64.0	14.6	8.8
Unmarried	165,545	9.9	60.0	19.6	10.5

\* Up to 9 years of schooling and before completion of 10 years, i.e., just before completion of school level. SC, Scheduled Caste; SLI, standard-of-living index; ST, Scheduled Tribe

a.  $p < .001$  for all covariates ( $\chi^2$  test of the contingency table of number of girls).

b. Severe anemia is defined as a hemoglobin level  $< 7.0$  g/dL, moderate anemia as a hemoglobin level between 7.0 and 9.9 g/dL, and mild anemia as a hemoglobin level between 10.0 and 11.9 g/dL; hemoglobin levels  $\geq 12.0$  g/dL are considered normal.

more likely to be anemic (OR = 1.027; 95% CI, 1.001 to 1.053) than rural girls. Thus, education and household standard of living are the main causes of differences in levels of anemia between urban and rural areas. The girls aged 10 to 14 years had a higher prevalence of anemia than girls aged 15 to 19 years in models 2 and 3, but the difference between the age groups disappears in models 4 and 5. **Table 4** further confirms our finding that the differences between rural and urban areas in

the prevalence of anemia are associated with the household SLI and the educational level of the adolescent girls. It also clearly shows that there is no effect of age on the anemia status of the girls.

The effect of other variables on the response variable does not change over different models in **tables 3 and 4**. In the models 2, 3, 4, and 5, unmarried girls have significantly lower odds of being anemic than married girls, even after controlling for rural or urban

TABLE 3. Determinants of moderate or severe anemia in adolescent girls according to logistic regression models<sup>a</sup>

Covariate	Odds ratio (95% confidence interval)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Residence					
Rural (reference)	—	—	—	—	—
Urban	0.940*** (0.919–0.960)	0.954*** (0.933–0.975)	0.976** (0.955–0.998)	1.019 (0.994–1.045)	1.027* (1.001–1.053)
Age (yr)					
15–19 (reference)		—	—	—	—
10–14		1.034*** (1.012–1.056)	1.027** (1.005–1.049)	0.989 (0.966–1.013)	0.995 (0.971–1.019)
Marital status					
Married (reference)		—	—	—	—
Unmarried		0.704*** (0.673–0.736)	0.732*** (0.700–0.765)	0.779*** (0.744–0.815)	0.792*** (0.756–0.830)
Religion and caste					
ST (non-Chris- tian) (reference)			—	—	—
ST (Christian)			0.209*** (0.193–0.226)	0.216*** (0.199–0.233)	0.550*** (0.503–0.602)
Hindu (SC)			1.009 (0.956–1.054)	1.026 (0.982–1.072)	1.030 (0.984–1.077)
Others Hindus			0.888*** (0.855–0.922)	0.925*** (0.890–0.961)	0.904*** (0.869–0.941)
Muslim			0.686*** (0.656–0.718)	0.700*** (0.669–0.733)	0.705*** (0.673–0.7390)
Others			0.942** (0.889–0.998)	1.000 (0.943–1.062)	0.953* (0.897–1.013)
Educational level of adolescent girls					
Illiterate (reference)				—	—
Up to class IX <sup>b</sup>				0.884*** (0.857–0.912)	0.922*** (0.894–0.951)
X and above				0.792*** (0.759–0.827)	0.862*** (0.826–0.900)
SLI index					
Low (reference)				—	—
Medium				0.937*** (0.913–0.962)	0.932*** (0.907–0.957)
High				0.953*** (0.923–0.985)	0.916*** (0.886–0.947)
Zone					
West (reference)					—
North					0.806*** (0.775–0.838)
East					0.729*** (0.699–0.759)
Central					0.725*** (0.697–0.754)
South					0.422*** (0.405–0.440)

continued

TABLE 3. Determinants of moderate or severe anemia in adolescent girls according to logistic regression models<sup>a</sup> (continued)

Covariate	Odds ratio (95% confidence interval)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Northeast					0.215*** (0.202–0.229)
Island					0.212*** (0.184–0.244)
Constant	2.422***	3.287***	3.671***	3.935***	5.577***
–2 log likelihood	215963.2	215714.5	213583.2	213398.7	209304.0
R <sup>2</sup> (Cox and Snell)	0.000	0.002	0.013	0.015	0.037

SC, Scheduled Caste; SLI, standard-of-living index; ST, Scheduled Tribe

a. A dash (—) in a cell indicates reference category. Anemia (hemoglobin < 12 g/dL = 1).

b. Up to 9 years of schooling and before completion of 10 years, i.e., just before completion of school level.

\* $p < .05$ , \*\* $p < .01$ ; \*\*\* $p < .001$ .

TABLE 4. Determinants of severe anemia in adolescent girls according to logistic regression models<sup>a</sup>

Covariate	Odds ratio (95% confidence interval)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Residence					
Rural (reference)	—	—	—	—	—
Urban	0.912*** (0.882–0.943)	0.915*** (0.884–0.946)	0.950*** (0.918–0.983)	1.017 (0.978–1.057)	1.013 (0.974–1.053)
Age (yr)					
15–19 (reference)	—	—	—	—	—
10–14		0.870*** (0.842–0.898)	0.866*** (0.838–0.894)	0.834*** (0.805–0.864)	0.842*** (0.812–0.872)
Marital status					
Married (reference)	—	—	—	—	—
Unmarried		0.828*** (0.781–0.878)	0.854*** (0.806–0.906)	0.925** (0.870–0.982)	0.940** (0.885–0.999)
Religion and caste					
ST (non-Christian) (reference)			—	—	—
ST (Christian)			0.318*** (0.269–0.375)	0.329*** (0.279–0.389)	0.487*** (0.405–0.585)
Hindu (SC)			0.784*** (0.740–0.831)	0.797*** (0.752–0.845)	0.882*** (0.831–0.937)
Other Hindus			0.686*** (0.652–0.721)	0.720*** (0.684–0.758)	0.764** (0.725–0.805)
Muslim			0.648*** (0.600–0.683)	0.649*** (0.608–0.693)	0.704*** (0.659–0.753)
Others			0.754*** (0.695–0.818)	0.814*** (0.749–0.885)	0.870*** (0.799–0.947)
Educational level of adolescent girls					
Illiterate (reference)				—	—
Up to class IX*				0.852*** (0.816–0.889)	0.833*** (0.798–0.870)
X and above				0.755*** (0.708–0.804)	0.758*** (0.711–0.808)

continued

TABLE 4. Determinants of severe anemia in adolescent girls according to logistic regression models<sup>a</sup> (continued)

Covariate	Odds ratio (95% confidence interval)				
	Model 1	Model 2	Model 3	Model 4	Model 5
SLI index					
Low (reference)				—	—
Medium				0.977 (0.940–1.015)	0.974 (0.937–1.014)
High				0.909*** (0.865–0.956)	0.896*** (0.851–0.944)
Zone					
West (reference)					—
North					0.588*** (0.559–0.619)
East					0.586*** (0.555–0.618)
Central					0.627*** (0.598–0.659)
South					0.468*** (0.441–0.498)
Northeast					0.421*** (0.377–0.470)
Island					0.344*** (0.251–0.471)
Constant	0.115***	0.148***	0.198***	0.211***	0.318***
–2 log likelihood	116020.94	115871.97	115489.00	115359.25	114570.06
R <sup>2</sup> (Cox and Snell)	0.000	0.001	0.003	0.004	0.008

SC, Scheduled Caste; SLI, standard-of-living index; ST, Scheduled Tribe

a. Severe anemia (hemoglobin < 7 g/dL = 1).

b. Up to 9 years of schooling and before completion of 10 years, i.e., just before completion of school level.

\**p* < .05, \*\**p* < .01; \*\*\**p* < .001.

habitation, age group, religion and caste, girl's education SLI, and zone in model 5 (OR = 0.792; 95% CI, 0.756 to 0.830) (**table 3**). Christian Scheduled Tribes, other Hindus, Muslims, and "other" communities in India have significantly lower odds of being anemic than non-Christian Scheduled Tribes after controlling for the rest of the covariates in model 5. However, Hindu Scheduled Castes have higher odds ratios than non-Christian Scheduled Tribes. In model 5, the odds of being anemic are significantly lower in literate girls than in illiterate girls and are also significantly lower in girls living in high-SLI households (OR = 0.916; 95% CI, 0.886 to 0.947) and medium-SLI households (OR = 0.932; 95% CI, 0.907 to 0.957) than in girls living in low-SLI households. Finally, girls from the north, east, central, south, northeast, and island zones are significantly less likely to be anemic than those from the west zone. The odds ratios for anemia in model 5 are lowest in girls from the northeast zone (OR = 0.215; 95% CI, 0.202 to 0.229) and the island zone (OR = 0.212; 95% CI, 0.184 to 0.244). The results are similar for the other response variable, severe anemia (**table 4**).

## Discussion

This study presents the hemoglobin status and prevalence of anemia among adolescent girls in the 35 states and union territories of India. The mean hemoglobin level was 9.89 g/dL, and the prevalence of anemia was as high as 90%. A recent study found a similar prevalence of anemia (90.1%), with a prevalence of severe anemia of 7.1%, among adolescent girls from 16 districts of 11 states, mainly from the northern and eastern parts of India [1]. Among adolescent girls of Nepal, a neighboring country, the prevalence of anemia (68.8%) was lower than that of Indian girls [22]. Within India, the highest prevalence of anemia is found in Jharkhand State in the eastern part of the country, where almost all adolescent girls are anemic. This state has a high concentration of non-Christian Scheduled Tribes (26.3%) who live in poor socioeconomic conditions [4]. The lowest prevalence rates of anemia are found in states in the northeastern region. People in this part of the country have a higher standard of living, possibly due to a high concentration of Christian Scheduled Tribes in this area. Sidhu et al. reported a high prevalence of severe anemia among adolescent girls, especially those

15 years of age or older, in Putlighar and Karimpura of Amritsar City [23]. Rajaratnam and Asokan documented a higher prevalence of anemia in girls who had attained menarche [24]. Low hemoglobin levels can be a major cause of delayed menarche [11]. Heath et al. found that high menstrual blood loss was associated with an increased risk of anemia [15]. At the national level, illiterate girls living in rural households with low SLI have a higher prevalence of severe anemia. Overall prevalence among urban and rural girls in Andhra Pradesh was 25%. Vasanthi et al. found that the prevalence rates of anemia and iron deficiency were higher among rural than among urban poor girls, irrespective of age and menarcheal status [25]. However, they did not eliminate the effect of other variables, as was done in this study. Anemia among rural adolescent girls in the District of Meerut (Uttar Pradesh) was found to be due mainly to low socioeconomic status and illiteracy [18].

However, educational and socioeconomic status alone may not have any significant effect on anemia [26]. Logistic regression of baseline data showed that anemia is significantly more likely among girls who eat two or fewer meals in a day, have been sick in the previous year, and consume few iron-rich foods [27]. Verma et al. found a higher prevalence of anemia among vegetarian than nonvegetarian schoolgirls (66% vs. 38%) [28]. Hashizume et al. found that a high iron intake was significantly associated with a lower prevalence of anemia among schoolgirls (OR = 0.39; 95% CI, 0.16 to

0.93) [29]. In developing countries such as India, poor bioavailability of dietary iron coupled with low intake of iron derived from animal foods is a major etiological factor for anemia [19]. However, because of lack of data we have not analyzed the effect of these factors in our study.

## Conclusion

There are many other causes of anemia in adolescent girls, including low absorption of iron in the body, overcooking of food, and parasitic infection. Stoltzfus et al. found that 25% of all cases of anemia, 35% of cases of iron-deficiency anemia, and 73% of cases of severe anemia were attributable to hookworm infection [16].

Two results clearly emerge from this study. First, there is no effect of place of residence (rural vs. urban) or age on the likelihood of anemia among adolescent girls in India. Whatever correlations can be found between the level of anemia and the place of residence or age are due to not considering the effect of other variables simultaneously. Second, the standard of living of the household and the literacy status of the adolescent girls are the two most important factors in determining the anemia status of the girls. Once these two variables are taken into account, place of residence and age cease to have an effect on anemia status.

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## Appendix. Description of terms

### Variables for logistic regression analysis

**Place of residence:** Urban or rural. **Age:** 10–14 or 15–19 years. **Adolescent girls' education:** Illiterate, up to class IX, and X and above. **Standard-of-living index (SLI):** This index reflects the economic well-being of the household. The National Family Health Survey (NFHS-2) prepared the index with the use of a number of variables. Each variable is given a score according to the criteria described for each variable, as given below, and the sum of these scores is calculated. The SLI of the household can then be defined as the total score divided by the maximum possible score. Scores of 0 to 14, 15 to 24, and 25 to 67 are defined as low, medium, and high, respectively. The maximum possible score is 67. The variables considered and their possible scores are as follows: **House type:** 4 for pucca (made of bricks, sand, cement, etc.), 2 for semipucca, 0 for kachha (made of earth and/or wood). **Toilet facilities:** 4 for own flush toilet, 2 for public or shared flush toilet or own pit toilet, 1 for shared or public pit toilet, 0 for no facilities. **Source of lighting:** 2 for electricity; 1 for kerosene, gas, or oil; 0 for other source of lighting. **Main cooking fuel:** 2 for electricity, liquid petroleum gas, or biogas; 1 for coal, charcoal, or kerosene; 0 for other fuel. **Source**

**of drinking water:** 2 for pipe, hand pump, or well in residence, 1 for public tap, hand pump, or well; 0 for other source. **Separate room for cooking:** 1 for yes, 0 for no. **Ownership of house:** 2 for yes, 0 for no. **Ownership of agricultural land:** 4 for 5 acres or more, 3 for 2.0 to 4.9 acres, 2 for less than 2 acres or acreage not known, 0 for no agricultural land. **Ownership of irrigated land:** 2 for some irrigated land, 0 for none. **Ownership of livestock:** 2 for some livestock, 0 for none. **Ownership of durable goods:** 4 each for a car or tractor; 3 each for a moped or scooter or motorcycle, telephone, refrigerator, or color television; 2 each for a bicycle, electric fan, radio, sewing machine, black and white television, water pump, bullock cart, or thresher; 1 each for a mattress, pressure cooker, chair, cot or bed, table, or clock or watch. **Marital status:** Married or unmarried. **Hemoglobin level:** Following international standards, hemoglobin levels < 7.0 g/dL indicate severe, 7.0 to 9.9 g/dL moderate, and 10.0 to 11.9 g/dL mild anemia; levels ≥ 12.0 g/dL are considered normal.

**Religion and caste:** Here, we have taken six categories by combining caste and religious groups such as “Muslims”, “Hindu Scheduled Castes” (SC), “Scheduled Tribes” (ST) “non-Christians”, “Scheduled Tribes (ST) Christians”, “Hindu (others)” consisting of Other

Backward Classes and general caste Hindu and “Others” belonging to other religious groups such as Buddhists, Jains etc.

### **Zones**

For better understanding of the spatial distribution of adolescent anemia, the states in India are grouped into the following zones: Northeast: Arunachal Pradesh,

Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. East: Bihar, Jharkhand, Orissa, and West Bengal. West: Goa, Gujrat, Daman and Diu, Dadra and Nagar Haveli, and Maharashtra. North: Haryana, Himachal Pradesh, Jammu and Kashmir, Delhi, Punjab, Rajasthan, Chandigarh, and Uttranchal. South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Pondichery. Islands: Andaman and Nicobar, and Lakshadip.