

Prevalence and Determinants of Anaemia Among Adolescent Girls (10 To 19 Years) in a Rural Field Practice Area: A Community-Based Cross-Sectional Study

Vaishali Chandrashekhar Adhav¹, Rajesh Nikam²

^{1,2}Assistant Professor, Department of Community Medicine, B. K. L. Walawalkar Rural Medical College, Sawarde, Ratnagiri, Maharashtra, India

Received: 22-06-2021 / Revised: 11-07-2021 / Accepted: 15-08-2021

Corresponding author: Dr. Vaishali Chandrashekhar Adhav

Conflict of interest: Nil

Abstract

Background: Anaemia is common among adolescent girls in India and threatens their growth, schooling and future pregnancies. Rural girls, many of whom are out of school, are often missed by school-based surveys and programmes.

Aim: To estimate the prevalence of anaemia among adolescent girls aged 10 to 19 years in a rural field practice area and to identify its sociodemographic, nutritional, menstrual and programme-related determinants.

Materials and Methods: A community-based cross-sectional study was conducted from November 2021 to April 2022 in the rural field practice area of B. K. L. Walawalkar Rural Medical College, Ratnagiri, Maharashtra. A total of 300 adolescent girls were selected by systematic random sampling from household registers. Data were collected by house-to-house interview with a pretested questionnaire, followed by anthropometry. Haemoglobin was measured on capillary blood with a HemoCue Hb 201+ analyser, and anaemia was classified by World Health Organization age-specific cut-offs. Determinants were identified by binary logistic regression in IBM SPSS Statistics 26.0.

Results: The mean age of the girls was 14.2 ± 2.7 years and the mean haemoglobin 11.27 ± 2.01 g/dL. Anaemia was present in 186 girls (62.0%; 95% CI 56.4 to 67.3). It was mild in 24.0%, moderate in 33.3% and severe in 4.7% of girls. Prevalence was higher in late than in early adolescents (68.9% vs 56.4%, $p = 0.026$). Only 48.3% of girls had taken weekly iron-folic acid tablets in the past month and 57.0% had been dewormed in the past six months. On multivariable analysis, socioeconomic class IV and V was the only independent determinant of anaemia (AOR 2.22, 95% CI 1.36 to 3.61). No recent deworming (AOR 1.62, $p = 0.061$) and not taking iron-folic acid tablets (AOR 1.51, $p = 0.100$) showed raised odds that were not statistically significant.

Conclusion: Nearly two in three adolescent girls in this rural area were anaemic, and poverty was the main determinant. Supervised weekly iron-folic acid intake, biannual deworming, dietary counselling and outreach to poorer and out-of-school girls should be strengthened under Anaemia Mukh Bharat.

Keywords: Adolescent; Anemia, Iron-Deficiency; Cross-sectional studies; Hemoglobins; India; Rural population.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Anaemia is one of the most widespread public health problems in the world. In 2010, nearly one-third of the global population (32.9%) was anaemic. Iron deficiency was the leading cause, the burden was higher in females than in males in most regions, and South Asia had among the highest burdens [1].

The Global Burden of Disease Study 2019 showed that the point prevalence of anaemia among females was highest in the 15 to 19 year age group. Most cases worldwide were due to dietary iron deficiency [2]. In low-income and middle-income countries, anaemia results from several overlapping

causes. These include deficiencies of iron, folate and vitamin B12, infections such as hookworm and malaria, inflammation and inherited disorders of haemoglobin [3,4].

Adolescence, the period from 10 to 19 years, is a time of rapid physical growth. There are about 1.8 billion adolescents in the world, and 90% of them live in low-income and middle-income countries. Girls are especially vulnerable because cultural and gender norms often shape their access to food, schooling and health care [5]. The growth spurt and the onset of menstruation raise iron requirements just when dietary intake is often poor. Iron-

deficiency anaemia causes fatigue, reduced physical work capacity and impaired cognitive function [6]. In girls, it also carries over into pregnancy and raises the risk of low birth weight in the next generation.

In India, the National Family Health Survey-5 (2019 to 21) found anaemia in 59.1% of girls aged 15 to 19 years, higher than the 54.1% reported in the previous round. An analysis of earlier national data showed that anaemia among adolescent girls was more common in older girls, illiterate girls, rural residents, girls from poor households, Scheduled Tribes and married girls [7].

A multicentric survey by the Indian Council of Medical Research in 16 districts found anaemia in 90.1% of adolescent girls, with 7.1% severely anaemic [8]. Between 2006 and 2016, haemoglobin improved among children and pregnant women but not among non-pregnant women. The drivers of improvement were maternal schooling, programme coverage, socioeconomic status and sanitation [9]. The Comprehensive National Nutrition Survey found anaemia in 28.4% of Indian adolescents. Only 21.3% of anaemic adolescents had iron-deficiency anaemia, while 25.6% had folate or vitamin B12 deficiency anaemia and 31.4% had anaemia of other causes [10].

India has run iron supplementation programmes for adolescents for many years. The Adolescent Girls' Anaemia Control Programme in Gujarat gave supervised weekly iron-folic acid tablets through schools and Anganwadi centres. It reduced anaemia from 74.7% to 53.2% [11]. The programme was scaled up across 13 states and, in 2012, became the national Weekly Iron and Folic Acid Supplementation (WIFS) programme [12].

Coverage with iron and folic acid under the National Iron Plus Initiative, however, has remained poor, and anaemia prevalence has changed little over the decades [13]. The Anaemia Mukht Bharat strategy, launched in 2018, adds deworming, behaviour change communication, testing and treatment to supplementation. Most Indian studies of adolescent anaemia are school-based or come from hospital outpatient clinics.

Girls who have left school, who are married early or who live in remote hamlets are often missed. Little is known about anaemia among adolescent girls in the coastal Konkan region of Maharashtra. The present study was therefore done to estimate the prevalence and severity of anaemia among adolescent girls aged 10 to 19 years in a rural field practice area of Ratnagiri district. It also aimed to identify the sociodemographic, nutritional, menstrual, hygiene and programme-related factors associated with anaemia.

Materials and Methods

Study Design, Setting and Period: This was a community-based cross-sectional study. It was carried out in the rural field practice area of the Department of Community Medicine, B. K. L. Walawalkar Rural Medical College, which is served by the college's Rural Health Training Centre at Dervan, Taluka Chiplun, District Ratnagiri, Maharashtra. The centre caters to a population of about 19,400 in Dervan and the surrounding villages of the Konkan hills. Data were collected from November 2021 to April 2022.

Ethical Approval: The study was approved by the Institutional Ethics Committee of B. K. L. Walawalkar Rural Medical College before data collection began. Written informed consent was taken from a parent or guardian of each girl below 18 years, together with written assent from the girl. Girls aged 18 and 19 years gave their own written consent. The study followed the Declaration of Helsinki and the ICMR National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017). Interviews and blood sampling were done in privacy, with a female health worker present. Every girl found to be anaemic was given treatment with iron-folic acid according to the Anaemia Mukht Bharat guidelines. Girls with severe anaemia were referred to the teaching hospital for further evaluation.

Study Population: Adolescent girls aged 10 to 19 years who had lived in the study villages for at least six months were eligible. The following girls were excluded:

- girls who were pregnant;
- girls with a known haemoglobinopathy, such as sickle cell disease or thalassaemia, or another chronic illness;
- girls who had received a blood transfusion in the previous three months;
- girls who were acutely ill at the time of the visit;
- girls whose parents or guardians did not give consent.

Sample Size and Sampling: Sample size was calculated with the formula $n = Z^2pq/d^2$. A study from a rural area of Tamil Nadu reported anaemia in 48.6% of adolescent girls [14], so p was taken as 48.6%. With an absolute precision (d) of 6% and a 95% confidence level ($Z = 1.96$), the minimum sample size was 267. After allowing 10% for non-response, the final sample size was 300. A line list of all adolescent girls aged 10 to 19 years was prepared from the household survey registers maintained by ASHAs and Anganwadi workers. The sample was allocated to each village in proportion to its number of adolescent girls. Girls were then selected within each village by systematic random sampling. If a selected girl was

not available after two visits, or was found to be illegible, the next girl on the list was taken.

Data Collection: Data were collected by house-to-house visits using a pretested semi-structured questionnaire in Marathi. The questionnaire was prepared in English, translated into Marathi and back-translated, and pilot tested on a small group of girls from a village outside the study area. Their data were not included in the analysis. It covered:

- sociodemographic details: age, religion, caste, schooling status, education of the girl and her mother, family type and size, and socioeconomic class by the modified B. G. Prasad scale updated for 2021;
- diet: vegetarian or mixed diet, and weekly frequency of green leafy vegetables, pulses, fruits, jaggery, eggs, meat and fish, and tea or coffee with meals;
- menstrual history: whether menarche had occurred, age at menarche, duration of menstrual flow and number of pads or cloths used per day;
- programme exposure: receipt and consumption of weekly blue iron-folic acid tablets under WIFS in the past month, and deworming with albendazole in the past six months;
- hygiene and sanitation: use of a toilet, handwashing with soap after defecation and before meals, and wearing footwear outdoors.

Anthropometry: Height was measured to the nearest 0.1 cm with a portable stadiometer, and weight to the nearest 0.1 kg with a calibrated digital weighing scale, following standard procedures. BMI-for-age and height-for-age z-scores were calculated with the WHO AnthroPlus software, version 1.0.4 (World Health Organization, Geneva). Thinness was defined as a BMI-for-age z-score below -2 SD, and stunting as a height-for-age z-score below -2 SD, using the WHO 2007 growth reference.

Haemoglobin estimation and definition of anaemia: Haemoglobin was measured on a finger-prick capillary blood sample with a HemoCue Hb 201+ analyser (HemoCue AB, Ängelholm, Sweden).

The device is widely used in field surveys and agrees well with laboratory reference methods [15]. The third drop of blood was used after the first two

drops were wiped away, and the device was checked daily with the manufacturer's control cuvette. Anaemia was defined by the WHO age-specific cut-offs: haemoglobin below 11.5 g/dL in girls aged 10 and 11 years, and below 12.0 g/dL in girls aged 12 to 19 years. Severity was graded by the WHO criteria. In girls aged 12 to 19 years, mild anaemia was 11.0 to 11.9 g/dL, moderate anaemia 8.0 to 10.9 g/dL and severe anaemia below 8.0 g/dL. In girls aged 10 and 11 years, mild anaemia was 11.0 to 11.4 g/dL, with the same thresholds for moderate and severe anaemia.

Statistical Analysis: Data were entered in Microsoft Excel and analysed with IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean and standard deviation (SD), and categorical variables as frequency and percentage. The prevalence of anaemia was reported with its 95% confidence interval (CI). Mean haemoglobin was compared between early (10 to 14 years) and late (15 to 19 years) adolescents with the independent samples t-test. The chi-square test was used for categorical comparisons. Binary logistic regression was used to identify the determinants of anaemia.

Variables with $p < 0.20$ on univariable analysis were entered into the multivariable model. Results were expressed as crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% CI. Multicollinearity was checked with the variance inflation factor, and model fit with the Hosmer-Lemeshow test. A p value below 0.05 was taken as statistically significant.

Results

A total of 300 adolescent girls took part. Their mean age was 14.2 ± 2.7 years. Of these, 165 (55.0%) were early adolescents aged 10 to 14 years, and 40 (13.3%) were not attending school. Menarche had occurred in 229 (76.3%) girls, at a mean age of 12.2 ± 1.2 years. Thirty-two (10.7%) girls were thin and 29 (9.7%) were stunted.

Although 193 (64.3%) girls had received weekly iron-folic acid tablets in the past month, only 145 (48.3%) had taken them. A total of 171 (57.0%) had been dewormed in the past six months. Table 1 shows the characteristics of the participants.

Table 1: Sociodemographic, nutritional and other characteristics of participants (n = 300)

Characteristic	Number	Percentage
Age group		
Early adolescence (10 to 14 years)	165	55.0
Late adolescence (15 to 19 years)	135	45.0
Schooling status		
Attending school or college	260	86.7
Not attending school	40	13.3
Girl's education		
Primary	67	22.3
Middle	118	39.3
Secondary	89	29.7
Higher secondary	26	8.7
Mother's education		
Illiterate or primary	166	55.3
Secondary and above	134	44.7
Type of family		
Nuclear	156	52.0
Joint or three-generation	144	48.0
Family size more than five	169	56.3
Socioeconomic class (modified B. G. Prasad)		
Class I to III	136	45.3
Class IV and V	164	54.7
Vegetarian diet	154	51.3
Green leafy vegetables less than three days a week	119	39.7
Tea or coffee with meals	123	41.0
Menarche attained	229	76.3
Menstrual flow more than five days*	82	35.8
Thinness (BMI-for-age below -2 SD)	32	10.7
Stunting (height-for-age below -2 SD)	29	9.7
WIFS tablets received in the past month	193	64.3
WIFS tablets consumed in the past month	145	48.3
Dewormed in the past six months	171	57.0
Toilet use	226	75.3
Handwashing with soap after defecation	214	71.3
Footwear worn outdoors	246	82.0

* Among girls who had attained menarche (n = 229). WIFS: Weekly Iron and Folic Acid Supplementation; BMI: body mass index; SD: standard deviation.

The mean haemoglobin was 11.27 ± 2.01 g/dL (range 6.1 to 14.7). Anaemia was present in 186 girls, a prevalence of 62.0% (95% CI 56.4 to 67.3). Of all participants, 72 (24.0%) had mild, 100 (33.3%) moderate and 14 (4.7%) severe anaemia

(Table 2, Figure 1). Late adolescents had a lower mean haemoglobin than early adolescents (10.95 ± 2.08 vs 11.53 ± 1.92 g/dL, $p = 0.012$), and a higher prevalence of anaemia (68.9% vs 56.4%, $p = 0.026$).

Table 2: Haemoglobin level and severity of anaemia by age group

Measure	10 to 14 years	15 to 19 years	Total
Number examined	165	135	300
Mean haemoglobin (g/dL) $\pm$ SD	11.53 ± 1.92	10.95 ± 2.08	11.27 ± 2.01
No anaemia, n (%)	72 (43.6)	42 (31.1)	114 (38.0)
Mild anaemia, n (%)	39 (23.6)	33 (24.4)	72 (24.0)
Moderate anaemia, n (%)	49 (29.7)	51 (37.8)	100 (33.3)
Severe anaemia, n (%)	5 (3.0)	9 (6.7)	14 (4.7)
Any anaemia, n (%)	93 (56.4)	93 (68.9)	186 (62.0)

Anaemia and severity were defined by WHO age-specific cut-offs (see Methods). Percentages are of girls examined in each column. SD: standard deviation. Difference in mean haemoglobin, t-test $p = 0.012$; difference in prevalence of anaemia, chi-square test $p = 0.026$.

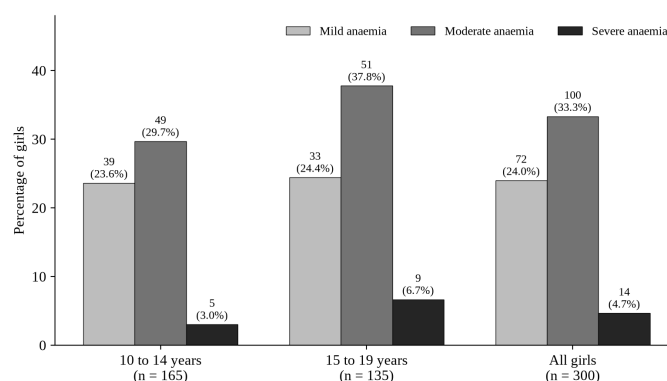


Figure 1: Severity of anaemia by age group

Bars show the percentage of girls in each age group with mild, moderate and severe anaemia, defined by WHO age-specific cut-offs. Labels give the number and percentage.

On univariable analysis, anaemia was significantly more common in late adolescents (68.9% vs 56.4%, $p = 0.026$) and in girls from socioeconomic class IV and V (70.1% vs 52.2%, $p = 0.001$) (Table 3). Anaemia was also more common in girls who had

not been dewormed in the past six months (68.2% vs 57.3%, $p = 0.054$) and in those who had not taken WIFS tablets (66.5% vs 57.2%, $p = 0.101$), but these differences were not statistically significant.

Schooling, mother's education, family type and size, diet, tea or coffee with meals, menstrual flow, thinness, stunting and hygiene practices were not associated with anaemia.

Table 3: Factors associated with anaemia on univariable analysis

Factor (present)	Anaemia in those with factor, n/N (%)	Anaemia in those without factor, n/N (%)	COR (95% CI)	p value
Late adolescence (15 to 19 years)	93/135 (68.9)	93/165 (56.4)	1.71 (1.06 to 2.76)	0.026
Not attending school	29/40 (72.5)	157/260 (60.4)	1.73 (0.83 to 3.61)	0.142
Mother illiterate or primary educated	106/166 (63.9)	80/134 (59.7)	1.19 (0.75 to 1.90)	0.461
Joint or three-generation family	91/144 (63.2)	95/156 (60.9)	1.10 (0.69 to 1.76)	0.682
Family size more than five	100/169 (59.2)	86/131 (65.6)	0.76 (0.47 to 1.22)	0.252
Socioeconomic class IV and V	115/164 (70.1)	71/136 (52.2)	2.15 (1.34 to 3.45)	0.001
Vegetarian diet	101/154 (65.6)	85/146 (58.2)	1.37 (0.86 to 2.18)	0.189
Green leafy vegetables less than three days a week	78/119 (65.5)	108/181 (59.7)	1.29 (0.80 to 2.08)	0.305
Tea or coffee with meals	77/123 (62.6)	109/177 (61.6)	1.04 (0.65 to 1.68)	0.858
Menarche attained	147/229 (64.2)	39/71 (54.9)	1.47 (0.86 to 2.52)	0.160
Menstrual flow more than five days*	55/82 (67.1)	92/147 (62.6)	1.22 (0.69 to 2.15)	0.497
Thinness	20/32 (62.5)	166/268 (61.9)	1.02 (0.48 to 2.18)	0.951
Stunting	16/29 (55.2)	170/271 (62.7)	0.73 (0.34 to 1.58)	0.425
No WIFS tablets in the past month	103/155 (66.5)	83/145 (57.2)	1.48 (0.93 to 2.36)	0.101
No deworming in the past six months	88/129 (68.2)	98/171 (57.3)	1.60 (0.99 to 2.58)	0.054
No toilet use	46/74 (62.2)	140/226 (61.9)	1.01 (0.59 to 1.73)	0.974
No handwashing with soap after defecation	54/86 (62.8)	132/214 (61.7)	1.05 (0.63 to 1.76)	0.858
No handwashing with soap before meals	54/84 (64.3)	132/216 (61.1)	1.15 (0.68 to 1.93)	0.611
No footwear outdoors	34/54 (63.0)	152/246 (61.8)	1.05 (0.57 to 1.93)	0.872

* Among girls who had attained menarche ($n = 229$). COR: crude odds ratio; CI: confidence interval; WIFS: Weekly Iron and Folic Acid Supplementation. Percentages are row percentages. The reference category for each factor is its absence. Chi-square test.

Seven variables with $p < 0.20$ were entered into the multivariable model (Table 4, Figure 2). No variance inflation factor exceeded 1.35. After adjustment, only socioeconomic class IV and V

remained independently associated with anaemia (AOR 2.22, 95% CI 1.36 to 3.61, $p = 0.001$). No deworming in the past six months (AOR 1.62, 95% CI 0.98 to 2.69, $p = 0.061$), not taking WIFS tablets

(AOR 1.51, 95% CI 0.92 to 2.46, $p = 0.100$) and late adolescence (AOR 1.57, 95% CI 0.89 to 2.79, $p = 0.118$) showed raised odds that did not reach

statistical significance. The model fitted the data well (Hosmer-Lemeshow $p = 0.695$; Nagelkerke $R^2 = 0.105$).

Table 4: Determinants of anaemia on multivariable logistic regression

Factor	AOR (95% CI)	p value
Late adolescence (15 to 19 years)	1.57 (0.89 to 2.79)	0.118
Not attending school	1.32 (0.59 to 2.98)	0.500
Socioeconomic class IV and V	2.22 (1.36 to 3.61)	0.001
Vegetarian diet	1.33 (0.81 to 2.17)	0.255
Menarche attained	1.12 (0.60 to 2.08)	0.728
No WIFS tablets in the past month	1.51 (0.92 to 2.46)	0.100
No deworming in the past six months	1.62 (0.98 to 2.69)	0.061

AOR: adjusted odds ratio; CI: confidence interval; WIFS: Weekly Iron and Folic Acid Supplementation. All seven variables were entered together (enter method). Hosmer-Lemeshow $p = 0.695$; Nagelkerke $R^2 = 0.105$.

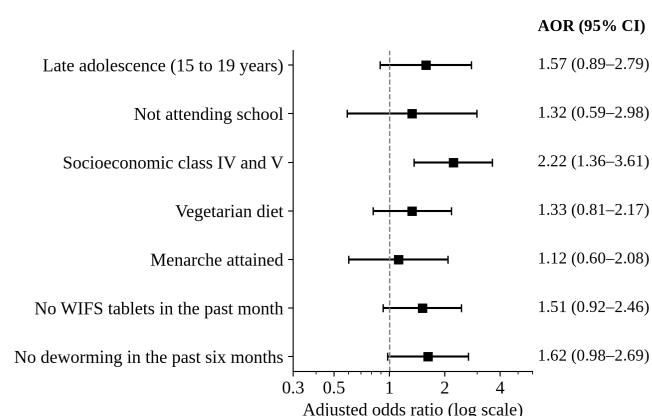


Figure 2: Adjusted odds ratios for anaemia

Squares show adjusted odds ratios and horizontal lines show 95% confidence intervals on a log scale. The dashed line marks an odds ratio of 1.

Discussion

This community-based study found anaemia in 62.0% of adolescent girls in a rural area of Ratnagiri district. Over half of the anaemic girls had moderate anaemia, and 4.7% of all girls were severely anaemic. By WHO criteria, a prevalence of 40% or more in a population is a severe public health problem, so anaemia is a severe public health problem among adolescent girls in this area. Our figure is close to the 59.1% reported among girls aged 15 to 19 years in the National Family Health Survey-5.

Our prevalence is lower than the 87% reported among 1010 adolescent girls in rural Maharashtra, where 65% had moderate anaemia [16], and the 90.1% found in the ICMR district survey [8]. It is higher than the 48.6% reported in rural Tamil Nadu [14], the 21% found in central Kerala [17], the 23.9% among school-going girls in Chandigarh [18] and the 44% among school children in Ernakulam [19]. The national estimate of 28.4% from the Comprehensive National Nutrition Survey included boys, who have lower rates [10].

Differences in age range, sampling, haemoglobin method and regional diet explain much of this variation. Studies drawn only from schools may underestimate anaemia, because out-of-school girls are often poorer and less well nourished. In our study, 72.5% of girls who were not in school were anaemic, compared with 60.4% of those attending school.

Late adolescents had a lower mean haemoglobin and more anaemia than early adolescents. The association weakened after adjustment, probably because age overlaps with menarche and with leaving school. In rural Maharashtra, the odds of anaemia rose by 41% with each year of age [16]. In rural Tamil Nadu, anaemia was more common in late adolescents and in girls from low socioeconomic classes [14]. Older girls in Ernakulam also had higher odds [19]. Rising iron loss after menarche, together with the rapid growth of adolescence, raises iron demand during these years [5,6]. The pattern is not universal: in South Ethiopia, early adolescents had higher odds of anaemia than late adolescents [20].

Lower socioeconomic class was the only factor independently associated with anaemia, and it more than doubled the odds. National data have also

shown that anaemia among adolescent girls is concentrated in poor and illiterate households [7]. Socioeconomic status and maternal schooling were among the main drivers of change in anaemia in India between 2006 and 2016 [9]. Poverty limits access to iron-rich foods such as meat, eggs and pulses, and to sanitation and health care [3]. This finding suggests that anaemia control in this area should give priority to girls from class IV and V households.

Diet, thinness and stunting were not associated with anaemia in our study. In rural Maharashtra, by contrast, a mid-upper arm circumference of 22 cm or more and eating fruit three or more days a week were protective [16]. In Ernakulam, regular tea or coffee with meals raised the odds of anaemia [19]. Tea and coffee contain polyphenols that block the absorption of non-haem iron from vegetarian meals [6]. Our simple weekly food frequency questions may not have captured the actual quantity of iron eaten, and only 32 girls were thin, which limited the power to detect an effect. Anaemia among Indian adolescents is also not caused only by iron deficiency. The national survey found that folate or vitamin B12 deficiency accounted for a quarter of anaemia among adolescents, and that many cases had other causes [10]. Diet counselling should therefore promote a diverse diet and not just iron tablets.

Menstrual flow lasting more than five days was not associated with anaemia. In central Kerala, the number of pads used per day was an independent risk factor [17]. Self-reported duration of flow is a crude measure of menstrual blood loss, which is an important and often unrecognised cause of iron deficiency in girls [6]. The same Kerala study found that worm infestation was a risk factor and that handwashing and footwear use were protective [17]. We found no link with hygiene practices. However, girls who had not been dewormed in the past six months had higher odds of anaemia, although the difference just missed statistical significance. A systematic review showed that treatment with albendazole raised mean haemoglobin by 1.89 g/L [21]. Only 57.0% of our girls had been dewormed in the past six months, so regular biannual deworming in schools and Anganwadi centres, including for girls who are not in school, needs strengthening.

Iron supplementation is the main strategy for preventing iron-deficiency anaemia in low-income and middle-income countries, along with food fortification and improved dietary diversity [22]. A Cochrane review found that intermittent iron supplementation reduced the risk of anaemia in menstruating women by 35% [23]. In our study, 64.3% of girls had received WIFS tablets in the past month, but only 48.3% had taken them. Girls who had not taken the tablets had higher odds of

anaemia, although this was not statistically significant. In urban Puducherry, 67.7% of school adolescents complied with WIFS, yet 62.7% were anaemic [24]. In national data, iron-deficiency anaemia among Indian women fell by only 3.5 percentage points between 2005 to 06 and 2015 to 16, and rose in some states, despite long-running supplementation programmes [25]. Poor supply, irregular distribution and low compliance have limited the impact of these programmes [13]. Supervised weekly dosing, as in the Gujarat programme [11], is more likely to work than simply handing out tablets.

Strengths and Limitations: The study has several strengths. It was based in the community and included girls who were not in school. It used random sampling, measured haemoglobin with a validated field device and assessed a wide range of risk factors. There are also limitations. The cross-sectional design does not allow causal conclusions. Diet, menstrual history and tablet intake were self-reported and may be subject to recall bias. Capillary haemoglobin measurement can be affected by sampling technique. Serum ferritin, vitamin B12, folate and stool examination were not done, so the type of anaemia could not be determined. Haemoglobinopathies were excluded only on the basis of history. The sample size was calculated for prevalence, so the study may have lacked power to detect modest associations with risk factors. The study covered a single rural area, which may limit how far the results can be generalised.

Conclusion

Nearly two in three adolescent girls in this rural area of Ratnagiri were anaemic, and over half of the anaemic girls had moderate or severe anaemia. Lower socioeconomic class was the only independent determinant. Lack of recent deworming, not taking weekly iron-folic acid tablets and late adolescence showed raised odds that did not reach statistical significance. Fewer than half of the girls had taken their weekly tablets in the past month. The WIFS and deworming components of Anaemia Mukht Bharat should be strengthened, with supervised tablet intake, priority for poorer households and active outreach to out-of-school girls through Anganwadi centres and ASHAs. Dietary counselling, menstrual health education and annual haemoglobin screening of all adolescent girls should be part of routine rural health services.

Acknowledgement: The author thanks the adolescent girls and their parents, the ASHAs and Anganwadi workers of the study villages, and the medical officer, staff and interns of the Rural Health Training Centre, B. K. L. Walawalkar Rural

Medical College, Ratnagiri, for their help with data collection.

Financial support and sponsorship: Nil.

Conflicts of interest: There are no conflicts of interest.

References

- Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, et al. A systematic analysis of global anemia burden from 1990 to 2010. *Blood*. 2014;123(5):615-24.
- Safiri S, Kolahi AA, Noori M, Nejadghaderi SA, Karamzad N, Bragazzi NL, et al. Burden of anemia and its underlying causes in 204 countries and territories, 1990-2019: results from the Global Burden of Disease Study 2019. *J Hematol Oncol*. 2021;14(1):185.
- Balarajan Y, Ramakrishnan U, Ozaltin E, Shankar AH, Subramanian SV. Anaemia in low-income and middle-income countries. *Lancet*. 2011;378(9809):2123-35.
- Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. *Ann N Y Acad Sci*. 2019;1450(1):15-31.
- Christian P, Smith ER. Adolescent undernutrition: global burden, physiology, and nutritional risks. *Ann Nutr Metab*. 2018;72(4):316-28.
- Camaschella C. Iron-deficiency anemia. *N Engl J Med*. 2015;372(19):1832-43.
- Bharati P, Shome S, Chakrabarty S, Bharati S, Pal M. Burden of anemia and its socioeconomic determinants among adolescent girls in India. *Food Nutr Bull*. 2009;30(3):217-26.
- Toteja GS, Singh P, Dhillon BS, Saxena BN, Ahmed FU, Singh RP, et al. Prevalence of anemia among pregnant women and adolescent girls in 16 districts of India. *Food Nutr Bull*. 2006;27(4):311-5.
- Nguyen PH, Scott S, Avula R, Tran LM, Menon P. Trends and drivers of change in the prevalence of anaemia among 1 million women and children in India, 2006 to 2016. *BMJ Glob Health*. 2018;3(5):e001010.
- Sarna A, Porwal A, Ramesh S, Agrawal PK, Acharya R, Johnston R, et al. Characterisation of the types of anaemia prevalent among children and adolescents aged 1-19 years in India: a population-based study. *Lancet Child Adolesc Health*. 2020;4(7):515-25.
- Kotecha PV, Nirupam S, Karkar PD. Adolescent girls' Anaemia Control Programme, Gujarat, India. *Indian J Med Res*. 2009;130(5):584-9.
- Aguayo VM, Paintal K, Singh G. The Adolescent Girls' Anaemia Control Programme: a decade of programming experience to break the inter-generational cycle of malnutrition in India. *Public Health Nutr*. 2013;16(9):1667-76.
- Kapil U, Kapil R, Gupta A. National Iron Plus Initiative: current status & future strategy. *Indian J Med Res*. 2019;150(3):239-47.
- Chandrakumari AS, Sinha P, Singaravelu S, Jaikumar S. Prevalence of anemia among adolescent girls in a rural area of Tamil Nadu, India. *J Family Med Prim Care*. 2019;8(4):1414-7.
- Sanchis-Gomar F, Cortell-Ballester J, Pareja-Galeano H, Banfi G, Lippi G. Hemoglobin point-of-care testing: the HemoCue system. *J Lab Autom*. 2013;18(3):198-205.
- Ahankari AS, Myles PR, Fogarty AW, Dixit JV, Tata LJ. Prevalence of iron-deficiency anaemia and risk factors in 1010 adolescent girls from rural Maharashtra, India: a cross-sectional survey. *Public Health*. 2017;142:159-66.
- Siva PM, Sobha A, Manjula VD. Prevalence of anaemia and its associated risk factors among adolescent girls of central Kerala. *J Clin Diagn Res*. 2016;10(11):LC19-23.
- Basu S, Basu S, Hazarika R, Parmar V. Prevalence of anemia among school going adolescents of Chandigarh. *Indian Pediatr*. 2005;42(6):593-7.
- Rakesh PS, George LS, Joy TM, George S, Renjini BA, Beena KV. Anemia among school children in Ernakulam district, Kerala, India. *Indian J Hematol Blood Transfus*. 2019;35(1):114-8.
- Shaka MF, Wondimagegne YA. Anemia, a moderate public health concern among adolescents in South Ethiopia. *PLoS One*. 2018;13(7):e0191467.
- Smith JL, Brooker S. Impact of hookworm infection and deworming on anaemia in non-pregnant populations: a systematic review. *Trop Med Int Health*. 2010;15(7):776-95.
- Pasricha SR, Drakesmith H, Black J, Hipgrave D, Biggs BA. Control of iron deficiency anemia in low- and middle-income countries. *Blood*. 2013;121(14):2607-17.
- Fernández-Gaxiola AC, De-Regil LM. Intermittent iron supplementation for reducing anaemia and its associated impairments in adolescent and adult menstruating women. *Cochrane Database Syst Rev*. 2019;1(1):CD009218.
- Wangaskar SA, Sahu SK, Majella MG, Rajaa S. Prevalence of anaemia and compliance to weekly iron-folic acid supplementation programme amongst adolescents in selected schools of urban Puducherry, India. *Niger Postgrad Med J*. 2021;28(1):44-50.
- Rai RK, Fawzi WW, Barik A, Chowdhury A. The burden of iron-deficiency anaemia among

women in India: how have iron and folic acid
interventions fared? WHO South East Asia J

Public Health. 2018;7(1):18-23.