ORIGINAL ARTICLE

Screening for Anemia among School-going Adolescents using a Digital Hemoglobinometer in Rural Dehradun District

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ABSTRACT

Background: Despite sustained governmental initiatives, anemia continues to be a public health concern among Indian adolescents. **Aims and Objectives:** To screen school-going adolescents for anemia and to assess utilization of Anemia Mukt Bharat (AMB)-related services. **Methodology:** A cross-sectional study was conducted among 381 school-going adolescents from selected schools within the rural field practice area of a medical college under a primary health center. Data were collected by personal interviews using a pretested tool. Hemoglobin (Hb) was estimated from capillary blood using a digital hemoglobinometer (HemocueHb 301). Malnutrition was assessed using standard growth charts. Data were analyzed using Statistical Package for Social Sciences version 20.0. **Results:** 39.1% of adolescents were found anemic. Three-fourths had never undergone routine anemia screening. Among those screened, most had annual testing, often via venous samples in private facilities, with out-of-pocket expenditure—contrary to AMB guidelines. Although most reported deworming in the past year, the majority had not received prophylactic IFA supplementation in the preceding week. Among those who did, only two-thirds consumed blue IFA tablets provided free through government facilities. Less than 10% were found stunted and wasted. **Conclusion:** A substantial anemia burden persists among adolescents, with poor utilization of AMB services, reflecting concerning state-level trends.

KEYWORDS

Anemia, Adolescents, Malnutrition, Screening, Iron and Folic acid

INTRODUCTION

Adolescence, defined as the age group of 10–19 years, is a crucial phase of physical and psychological development.(1) India has approximately 253 million adolescents, constituting one of the world's largest populations requiring adequate nutrition, education, counseling, and health support.(2) Anemia is a major global public health concern among adolescents, negatively affecting physical health, cognitive ability, academic performance, and quality of life.(3,4) In Uttarakhand, an Empowered Action Group (EAG) state, anemia prevalence remains high, particularly among adolescent girls (40.9%) compared to boys (27.6%) during 2020–21.(5,6)

Iron deficiency anemia is the most common type, arising from inadequate iron intake, menstrual blood loss, and increased physiological demands during adolescence. Other causes include folate and vitamin B12 deficiencies, infections such as helminthiasis and malaria, and genetic hemoglobinopathies.(7,8) Adolescent anemia results in stunted growth, reduced physical capacity, increased infection risk, poor cognitive

development, school dropouts, and long-term adverse outcomes.(9,10)

The Government of India (GoI) has been addressing anemia since 1970 through national programs. The Weekly Iron and Folic Acid Supplementation (WIFS) program was launched in 2013 under the National Iron Plus Initiative, along with biannual deworming.(11) In 2018, the Anemia Mukt Bharat (AMB) strategy was introduced, emphasizing point-of-care hemoglobin screening, supplementation, deworming, hygiene promotion, and behavior change communication. (12–14)

sTo assess the extent of implementation of the AMB strategy and its effect to avert anemia in the rural Dehradun district of Uttarakhand, the present study was primarily designed:

- To screen anemia among school-going adolescents in Dehradun district using a point-of-care digital hemoglobinometer and
- To evaluate utilization of AMB services.

MATERIAL & METHODS

Study Design, Setting, and Participants: The Department of Community Medicine conducted a cross-sectional study among school-going adolescents, natives of the rural field practice area affiliated to a private medical college in the Dehradun district. The field practice area comes under the administrative jurisdiction of a primary health center (PHC), Raiwala (Doiwala block). The PHC covers a rural population of 32,853 spread out in 14 villages along the banks of the Ganga River within a geographical area of 30 km^2. It has three sub-centers and 26 Aanganwadi centers with a total of registered 4,089 adolescents (both school-going and out-of-school) by March 2024.(15) Its catchment area has a total of 20 schools, out of which 12 schools have enrolled adolescents between classes 6 and 12 (995 males and 884 females) (school enrolment rate 45.9%).

The study participants included locally registered adolescents, studying in class from 6 to 12, and residing in rural areas for more than a year. Those pregnant, critically ill, and/or terminally ill, showing hostile behavior were excluded from the study. Considering 40.9% and 27.6% prevalences of anemia among adolescent girls and boys (5) with a 95% confidence level, 7.5% absolute precision, and a 10% non-response rate, a minimum of 182 adolescent girls and 150 boys were required to be recruited in the present study. Data were collected over five months from February to June 2024.

Study Variables and Instrument: Institutional ethical clearance and permission from the principals of 12 schools were sought before initiating the study. However, out of 12 schools, two denied permission. From the remaining ten, five schools were selected by maintaining an overall representation of school-going adolescents of 85%, and a minimum ratio of 1:1 at semi-govt., 1:3 at govt./private schools, and 1:1 to 1:2 to 1:3 at Pratit Nagar, Haripur Kala, and Raiwala sub-centers, respectively. From each selected school, the class-wise list of students enrolled in classes between 6-12 was retrieved from their attendance register. From each class, 10 adolescents (six girls and four boys as per the gender-wise ratio in the calculated sample size) were selected using simple random sampling without replacement by lottery method.

Two days before initiating data collection, adolescents fulfilling the inclusion criteria were provided subject information sheets and caregivers' informed consent forms to seek permission from their caregivers (parents/ guardians) and bring back the signed forms the next day. Those eligible adolescents who provided signed forms were explained about the study and given written informed assent. Those eligible and willing adolescents who provided both a signed informed consent form from their caregiver and a self-attested written informed assent were finally recruited in the study.

Data were collected using a pre-designed, semi-structured tool through personal face-to-face interviews. The tool consisted of five sections. In the first section, baseline socio-demographic information was collected. Socio-economic status (SES) was assessed using the modified Udai Pareekh scale 2021.(16) The second section gathered details regarding AMB practices, viz., anemia screening, weekly prophylactic IFA supplementation, and biannual deworming. In the third section, information was collected on anemia-related factors. The fourth section included anthropometric measurements. Height was measured using a standard measuring tape, taken to the nearest one centimeter. The adolescent was requested to stand upright barefoot, look forward with their back against the wall, and heels together. Weight was measured using a standard weighing scale (kgs) kept on a firm horizontal surface and recorded to the nearest 500 g. Malnutrition was assessed using a gender-specific combined World Health Organization (WHO) 2006 and Indian Academy of Paediatrics (IAP) 2015 height- and weight-for-age growth charts for 0-18 years that also has an in-built weight-for-height growth chart (also known as body mass index (BMI) quick assessment tool) for 8-18 years adolescents.(17)

The last section recorded the test results of capillary Hb values measured on-site using a point-of-care digital hemoglobinometer. In the present study, model HemoCue Hb 301 (hemoCue AB Angelhom, Sweden) was used to screen anemia by drawing capillary blood samples from an adolescent's right hand, ring finger. (14) It operates on a portable battery that uses HemoCue Hb 301 microcuvettes only. It measures Hb by estimating the absorbance of whole blood at Hb/HbO 2 isosbestic points of 506 nm and 880 nm wavelengths for turbidity compensation, giving quick results within seconds. It has 90% sensitivity, 80% specificity, 86% negative predictive value, 85% positive predictive value, and requires only 10 µL blood (capillary, venous, or arterial).

Operational Definitions

Anemia: If Hb values fall below the age-defined cut-offs as recommended by AMB guidelines (12):

i. **Those aged below 12 years:** <11.5 g/dL
ii. **Those aged between 12 and 15 years:** <12 g/dL
iii. **Those aged 15 years and above:**
iv. **Non-pregnant females:** ≤12 g/dL
v. **Males:** ≤13 g/dL

Malnutrition: On using gender-specific, combined WHO 2006 and IAP 2015

Height-for-age growth chart **(for 0-18 years)**, an adolescent is classified as **stunted** (below 3rd centile) or **normal** (between 3rd – 97th centile)

Weight-for-age growth chart **(for 0-18 years)**, an adolescent is classified as **underweight** (below 3rd centile) or **normal** (between 3rd – 97th centile)

Weight-for-height growth chart (for 8-18 years), also known as the **BMI quick assessment screening tool**, an adolescent is classified as **wasted**: below the underweight (UW) black line), **normal** (between UW black and overweight (OW) yellow lines), **overweight** (between OW yellow and obese (OB) in red lines), or **obese** (above OB red line)

SES class: On using the modified Udai Pareekh Scale 2021 (16), the adolescent is classified as belonging to **upper** (score ≥43), **upper-middle** (score between 33 and 42), **middle** (score between 24 and 32), **lower-middle** (score between 13 and 23), or **lower** (score <13) SES class

Significant blood loss: If the bleeding of any form (excluding menstruation) fails to stop naturally, and he/she requires medications of any form to stop bleeding.

Iron-rich foods: Adolescents were shown pictures of iron-rich food items viz., green leafy vegetables, dry fruits, and vitamin C for visual support and avoidance of recall bias.

Data Analysis: Data were entered and analyzed using Statistical Package for Social Sciences (SPSS), version 20.0. Categorical variables were expressed as percentages and proportions. The chi-square test or Fisher's Exact test was used to compare proportions in two groups. $P < 0.05$ was considered statistically significant.

RESULTS

The present study included 222 adolescent girls and 159 boys from five selected schools. **Table 1** revealed a similar distribution of baseline socio-demographic characteristics among recruited girls and boys. Pooled results show three-fourths were aged 12 years and above (mean age: 14.4 (±SD: 2.0) years). More than half were enrolled in non-govt. schools, studying in class 9th and above, and belonging to the upper-middle SES class. Most practiced Hinduism and had caregivers in marital relationships. More than one-third screened anemic; frequency rates being significantly higher among girls than boys (p=0.005). Using the combined WHO 2006 and IAP 2015 height- and weight-for-age growth charts, less than 10% of adolescents were stunted and wasted. On the BMI quick assessment tool, one-fourth were malnourished. Among malnourished adolescents, three-fourths were overweight/obese.

Figure 1 illustrates the gender-wise distribution of anemia among school-going adolescents in different age groups. Most anemia is screened among adolescents aged 12 years and above, with about two-thirds of girls being more anemic than boys in each age category.

Table 2 shows girls, stunted adolescents, and those enrolled in govt. schools have a significantly higher frequency of anemia than their counterparts (p<0.05).

Figure 2 illustrates the utilization rates of anemia screening practices by adolescents under AMB. Results showed that about three-fourths of adolescents had not been screened for anemia in the past. Among those who did, most underwent annual screening; about half gave venous samples, in private settings, and had even paid for the screening services. Notably, among those enrolled in govt. schools (167; 43.8%), only one-third (54; 32.3%) reported being screened for anemia.

Table 1: Baseline Socio-demographic Characteristics of School-going Adolescent Girls (N=222) and Boys (N=159)

Variables	Girls	Boys	Total	x^2; p-value
	N=222	N=159	N=381	
	n (%)	n (%)	n (%)	
Sub-centre				
Haripur Kala	63 (28.4)	47 (29.6)	110 (28.9)	
Pratitnagar	87 (39.2)	68 (42.8)	155 (40.7)	1.02; 0.59
Raiwala	72 (32.4)	44 (27.6)	116 (30.4)	
School sub-type				
Govt.	101 (45.5)	66 (41.6)	167 (43.9)	
Semi-govt.	46 (20.7)	39 (24.5)	85 (22.3)	0.94; 0.63
Private	75 (33.8)	54 (33.9)	129 (33.8)	
Age (in years)				
<12 years	47 (21.2)	35 (22.0)	82 (21.5)	
12-15 years	115 (51.8)	69 (43.4)	184 (48.3)	3.14; 0.20
≥15 years	60 (27.0)	55 (34.6)	115 (30.2)	
Classes				
6-8	89 (40.1)	63 (39.6)	152 (39.9)	
9-10	84 (37.8)	55 (34.6)	139 (36.5)	0.81; 0.66
11-12	49 (22.1)	41 (25.8)	90 (23.6)	
Religion				
Hindu	207 (93.2)	146 (92.4)	353 (92.9)	
Muslim	10 (4.5)	5 (3.2)	15 (3.9)	2.5; 0.45
Sikh	5 (2.3)	6 (3.8)	11 (2.9)	
Christian	0 (0.0)	1 (0.6)	1 (0.3)	
Caregiver's marital status				
Married	208 (93.7)	152 (95.5)	360 (94.5)	0.64; 0.42
Previously Married[#]	14 (6.3)	7 (4.5)	21 (5.5)	
SES Class[±]				
Upper	55 (24.8)	31 (19.5)	86 (22.6)	
Upper-middle	117 (52.7)	99 (62.3)	216 (56.7)	1.02; 0.59
Middle	44 (19.8)	18 (11.3)	62 (16.3)	
Lower-middle	6 (2.7)	11 (6.9)	17 (4.4)	
Anemia				
Present	100 (45.1)	49 (30.8)	149 (39.1)	7.8; **0.005**
Absent	122 (54.9)	110 (69.2)	232 (60.9)	
BMI*				
Underweight	13 (5.9)	12 (7.5)	25 (6.6)	
Normal	173 (77.9)	116 (73.0)	289 (75.9)	2.74; 0.43
Overweight	29 (13.1)	21 (13.2)	50 (13.1)	
Obese	7 (3.1)	10 (6.3)	17 (4.4)	
Height-for-age chart*				
Normal	209 (94.1)	136 (85.5)	345 (90.6)	8.02; **0.005**
Stunting	13 (5.9)	23 (14.5)	36 (9.4)	
Weight-for-age chart*				
Normal	216 (97.3)	152 (95.6)	368 (96.6)	0.81; 0.36
Wasting	6 (2.7)	7 (4.4)	13 (3.4)	

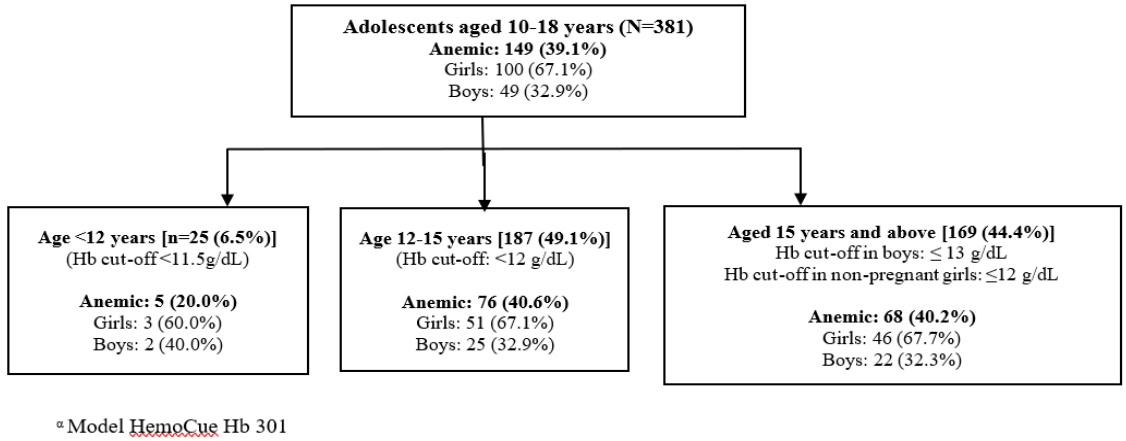
*Abbreviations: BMI: Body Mass Index; SES: Socio-economic status; [#]includes widow, divorced, separated; [±]No subject belonged to the lower class as per the Revised Udai Pareek socio-economic status scale 2021; *Combined WHO 2006 and IAP 2015 height and weight growth charts for 0-18 years, gender-specific, with a BMI quick assessment tool for 8-18 years*

Table 2: Baseline Socio-demographic Characteristics among Anemic (n=149) and Non-anemic Adolescents (n=232)

Variables	Anemic	Non-anemic	Total	x^2; p-value
	N=149	N=232	N=381	
	n (%)	n (%)	n (%)	
Gender				
Boys	49 (32.9)	110 (47.4)	159 (41.7)	**7.9;0.005**
Girls	100 (67.1)	122 (52.6)	222 (58.3)	
Sub-centre				
Haripur Kala	49 (32.9)	61 (26.3	110 (28.9)	
Pratitnagar	49 (32.9)	106 (72.4)	155 (40.7)	**6.2; 0.046**
Raiwala	51 (34.2)	65 (28.0)	116 (30.4)	
School sub-type (Govt. & non-govt.)				
Govt.	77 (51.7)	90 (38.8)	167 (43.8)	
Semi-govt.	26 (17.4)	59 (25.4)	85 (22.3)	**6.2; 0.046**
Private	46 (30.9)	83 (35.8)	129 (33.9)	
Age (in years)				
<12 years	5 (3.3)	20 (8.6)	25 (6.5)	
12-15 years	76 (51.0)	111 (47.8)	187 (49.1)	4.1; 0.128
≥15 years	68 (45.7)	101 (43.6)	169 (44.4)	
Classes				
6-8	52 (34.9)	99 (42.7)	151 (39.6)	
9-10	63 (42.3)	77 (33.2)	140 (36.7)	3.5; 0.175
11-12	34 (22.8)	56 (24.1)	90 (23.7)	
Religion				
Hindu	137 (91.9)	216 (93.2)	353 (92.6)	
Muslim	8 (5.4)	8 (3.4)	16 (4.2)	1.4; 0.685
Sikh	4 (2.7)	7 (3.0)	11 (2.9)	
Christian	0 (0.0)	1 (0.4)	1 (0.3)	
Caregiver's marital status				
Married	141 (94.6)	219 (94.4)	360 (94.5)	0.10; 0.922
Previously Married#	8 (5.4)	13 (5.6)	21 (5.5)	
SES Class±				
Upper	41 (27.5)	45 (19.4)	86 (22.6)	
Upper-middle	80 (53.7)	136 (58.6)	216 (56.7)	3.7; 0.286
Middle	21 (14.1)	41 (17.7)	62 (16.2)	
Lower-middle	7 (4.7)	10 (4.3)	17 (4.5)	
BMI*				
Underweight	6 (4.0)	19 (8.2)	25 (6.6)	
Normal	118 (79.2)	171 (73.7)	289 (75.9)	2.9; 0.393
Overweight	18 (12.1)	32 (13.8)	50 (13.1)	
Obese	7 (4.7)	10 (4.3)	17 (4.4)	
Height-for-age Chart*				
Normal	126 (84.6)	219 (94.4)	345 (90.6)	**10.2; 0.001**
Stunting	23 (15.4)	13 (5.6)	36 (9.4)	
Weight-for-age Chart*	145 (97.3)			
Normal	4 (2.7)	223 (96.1)	368 (96.6)	0.0; 0.774*
Wasting		9 (3.9)	13 (3.4)	

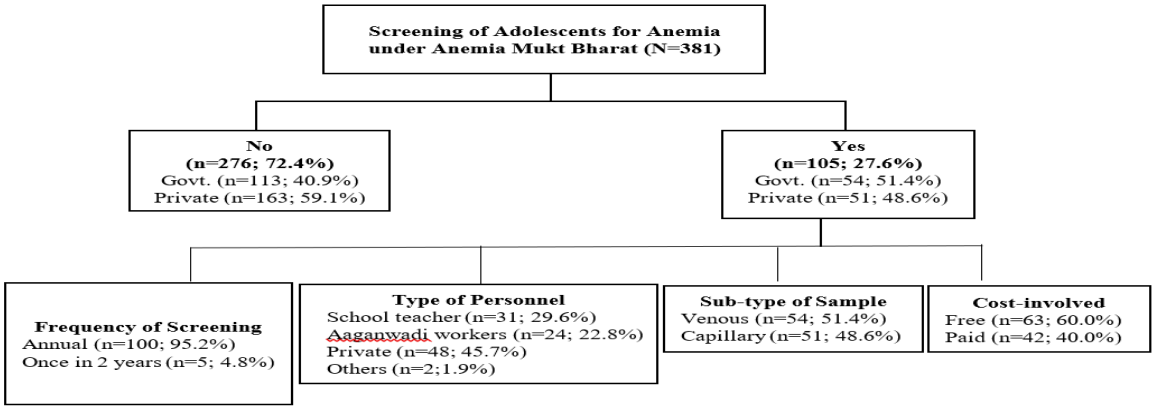
*Abbreviations: BMI: Body Mass Index; SES: Socio-economic status; #includes widow, divorced, separated; ±No subject belonged to the lower class as per the Revised Udai Pareek socio-economic status scale 2021; *Combined WHO 2006 and IAP 2015 height and weight growth charts for 0-18 years, gender-specific, with a BMI quick assessment tool for 8-18 years; *Fisher's exact test*

Figure 1: Gender-wise distribution of Anemia among School-going Adolescents in different age groups screened using a Point-of-care Digital Hemoglobinometerα (N=381)



α Model HemoCue Hb 301

Figure 2: Screening of Adolescents for Anemia under Anemia Mukt Bharat (N=381)



Figures 3 (a and b) illustrate about utilization rates of weekly prophylactic IFA supplementation and bi-annual deworming services by adolescents under AMB. Results showed most adolescents had undergone routine deworming in the past year but had not received prophylactic IFA supplementation in the preceding week. Among those remaining who had received prophylactic WIFS in the past week, two-thirds reported consuming blue-colored IFA tablets. all from govt. set-ups, at no cost. The most frequent side effect following routine IFA supplementation was nausea (22; 41.5%), followed by abdominal pain (11; 20.8%), dizziness (9; 17.0%), and black stools (7; 13.2%). Notably, among those enrolled in govt. schools, most underwent biannual deworming, but less than one-fifth consumed prophylactic IFA tablets in the preceding week.

Table 3 presents the association between anemia-related factors among anemic and non-anemic adolescents. Results show adolescents with a habit of skipping meals had a significantly higher frequency of anemia than those who didn't ($p<0.05$). Adolescents with anemia have significantly higher frequency rates of passing worms in stools and consuming meals less than 3 meals a day than non-anemic adolescents ($p<0.05$).

Table 3: Factors among Anemic (n=149) and Non-anemic Adolescents (n=232)

Variables	Anemic N=149 n (%)	Non-anemic N=232 n (%)	Total N=381 n (%)	χ^2; p-value
Symptoms in the past 3 months				
Weakness				
Yes	77 (51.7)	99 (42.7)	176 (46.2)	
No	72 (48.3)	133 (57.3)	205 (53.8)	2.9; 0.085
Dizziness				
Yes	54 (36.2)	68 (29.3)	122 (32.0)	
No	95 (63.8)	164 (70.7)	259 (68.0)	2.0; 0.157

Variables	Anemic N=149 n (%)	Non-anemic N=232 n (%)	Total N=381 n (%)	x^2; p-value
Headache				
Yes	82 (55.0)	123 (53.0)	205 (53.8)	
No	67 (45.0)	109 (47.0)	176 (46.2)	0.1; 0.700
Numbness/coldness				
Yes	35 (23.5)	45 (19.4)	80 (21.0)	
No	114 (76.5)	187 (80.6)	301 (79.0)	0.9; 0.338
Pale skin				
Yes	19 (12.8)	20 (8.6)	39 (10.2)	
No	130 (87.2)	212 (91.4)	342 (89.8)	1.7; 0.194
Irritability				
Yes	62 (41.6)	79 (34.1)	141 (37.0)	
No	87 (58.4)	153 (65.9)	240 (63.0)	2.2; 0.136
Hospitalization in the past 3 months				
Yes	5 (3.4)	7 (3.0)	12 (3.1)	
No	144 (96.6)	225 (97.0)	369 (96.9)	0.03; 0.854
Malaria episode in the past 3 months				
Yes	3 (2.1)	2 (0.9)	5 (1.3)	
No	146 (97.9)	230 (99.1)	376 (98.7)	0.0; 0.335*
Significant blood loss in the past 3 months				
Yes	6 (4.0)	8 (3.4)	14 (3.7)	
No	143 (96.0)	224 (96.6)	367 (96.3)	0.9; 0.770
Pass worms in stool				
Yes	12 (8.1)	7 (3.0)	19 (5.0)	
No	137 (91.9)	225 (97.0)	362 (95.0)	4.9; 0.028
Walking barefoot in fields				
Yes	95 (63.8)	161 (69.4)	256 (67.2)	
No	54 (36.2)	71 (30.6)	125 (32.8)	1.3; 0.253
Washing hands before meals				
Yes	145 (97.3)	228 (98.2)	373 (97.9)	0.0; 0.717
No	4 (2.7)	4 (1.8)	8 (2.1)	
Wash hands after using toilet				
Yes	148 (99.3)	229 (98.7)	377 (99.0)	
No	1 (0.7)	3 (1.3)	4 (1.0)	0.0; 1.00*
Heavy bleeding during menses (n=222)				
Yes	27 (27.0)	38 (31.1)	65 (29.2)	
No	73 (73.0)	84 (68.9)	157 (70.8)	0.4; 0.499
Pass blood clots during menses (n=222)				
Yes	25 (25.0)	19 (15.6)	44 (19.8)	
No	75 (75.0)	103 (84.4)	178 (80.2)	3.0; 0.080
Experienced prolonged bleeding during menses (n=222)				
Yes	33 (33.0)	32 (26.2)	65 (29.2)	
No	67 (67.0)	90 (73.8)	157 (70.8)	1.2; 0.270
Any time experienced cycle within 21 days (n=222)				
Yes	45 (45.0)	46 (37.7)	91 (41.0)	
No	55 (55.0)	76 (62.3)	131 (59.0)	1.2; 0.272
Smoking				
Yes	3 (2.0)	1 (0.4)	4 (1.0)	
No	146 (98.0)	231 (99.6)	377 (99.0)	0.0; 0.304*
Source of lunch				
Home-made	103 (69.1)	167 (72.0)	270 (70.9)	
School canteen	46 (30.9)	65 (28.0)	111 (29.1)	0.4; 0.549
Types of diet consumed				

Variables	Anemic N=149 n (%)	Non-anemic N=232 n (%)	Total N=381 n (%)	x^2; p-value
Vegetarian	76 (51.1)	95 (40.9)	171 (44.8)	3.71; 0.054
Non-vegetarian (including eggetarian)	73 (48.9)	137 (59.1)	210 (55.2)	
Frequency of meals per day				
<3	72 (48.3)	70 (30.2)	142 (37.3)	12.8;
≥3	77 (51.7)	162 (69.8)	239 (62.7)	<0.001
Habit of skipping meals				
Yes	91 (61.1)	115 (49.6)	206 (54.1)	
No	58 (38.9)	117 (50.4)	175 (45.9)	7.9; 0.02
Frequency of Millet consumption				
No	74 (49.7)	117 (50.4)	191 (50.1)	
<3 times a week	28 (18.8)	57 (24.6)	85 (22.3)	
≥3 times a week	47 (31.5)	58 (25.0)	105 (27.6)	2.8; 0.249
Frequency of Vitamin-C-rich foods consumption				
No	7 (4.7)	22 (9.5)	29 (7.6)	
<3 times a week	58 (38.9)	78 (33.6)	136 (35.7)	
≥3 times a week	84 (56.4)	132 (56.9)	216 (56.7)	3.4; 0.178
Frequency of Green Leafy Vegetables consumption				
No	10 (6.7)	14 (6.0)	24 (6.3)	
<3 times a week	43 (28.9)	47 (20.3)	90 (23.6)	
≥3 times a week	96 (64.4)	171 (73.7)	267 (70.1)	4.0; 0.134
Frequency of Dry Fruit consumption				
No	22 (14.7)	39 (16.8)	61 (16.0)	
<3 times a week	60 (40.3)	97 (41.8)	157 (41.2)	
≥3 times a week	67 (45.0)	96 (41.4)	163 (42.8)	0.6; 0.755
Frequency of Iron-fortified Milk consumption				
No	67 (45.0)	91 (39.2)	158 (41.5)	
<3 times a week	17 (11.4)	25 (10.8)	42 (11.0)	
≥3 times a week	65 (43.6)	116 (50.0)	181 (47.5)	1.6; 0.465
Frequency of Iron-fortified Edible Oil consumption				
No	46 (30.9)	76 (32.7)	122 (32.0)	
<3 times a week	9 (6.0)	18 (7.8)	27 (7.1)	
≥3 times a week	94 (63.1)	138 (59.5)	232 (60.9)	0.7; 0.714
Frequency of Iron-fortified Rice consumption				
No	40 (26.9)	67 (28.9)	107 (28.1)	
<3 times a week	9 (6.0)	12 (5.2)	21 (5.5)	
≥3 times a week	100 (67.1)	153 (65.9)	253 (66.4)	0.3; 0.871
Frequency of Iron-fortified Flour consumption				
No	42 (28.1)	65 (28.0)	107 (28.1)	
<3 times a week	5 (3.4)	6 (2.6)	11 (2.9)	
≥3 times a week	102 (68.5)	161 (69.4)	263 (69.0)	0.2; 0.905
Frequency of Iron-fortified Salt consumption				
No	32 (21.5)	57 (24.6)	89 (23.4)	
<3 times a week	5 (3.4)	5 (2.1)	10 (2.6)	
≥3 times a week	112 (75.1)	170 (73.3)	282 (74.0)	0.9; 0.633
***Fisher exact test**				

Figure 3a: Prophylactic IFA Supplementation of Adolescents in the past one week under Anemia Mukt Bharat (N=381)

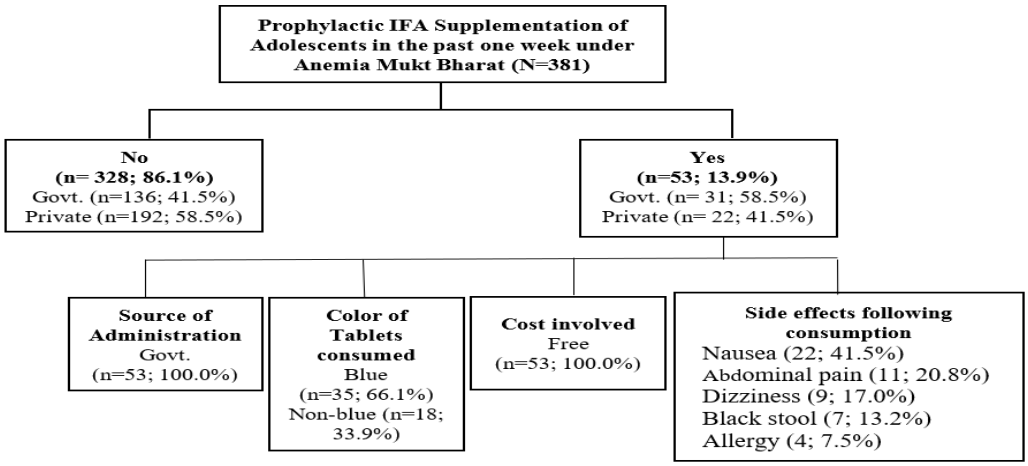
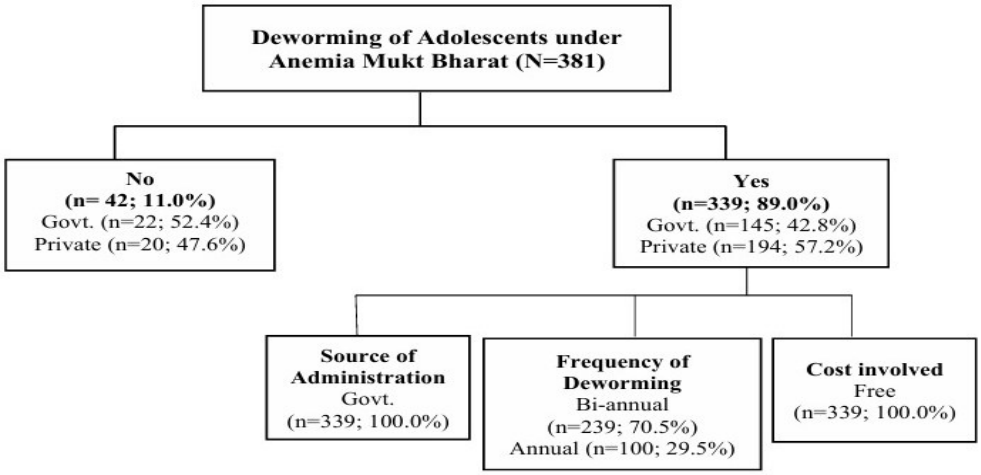


Figure 3b: Deworming of Adolescents under Anemia Mukt Bharat (N=381)



DISCUSSION

Studies conducted by Rakesh et al. (2019) and Verma et al. (2019) in the Ernakulam district (Kerala) (18) and Rajasthan (19) reported comparable prevalences. In rural Varanasi district (Uttar Pradesh), a school-based study reported a higher anemia burden (58%) among school-going adolescents.(20) The trends in the gender-wise anemia burden in the present study correspond closely with the state-level data from NFHS-5.(5) An invariably higher prevalence noted among both girls and boys underscores the need for gender-focused interventions in adolescence among both girls and boys.

The study done by Kamble et al. (2021) (21) reported that all participants used govt. services in the T-3 camp at no cost. Sethi et al. (2019) (22) found in their study that WIFS consumption in Haryana and Delhi was 85% and the most reported adverse effects were abdominal pain (80%) and nausea (10%). Sahoo et al. (2023) (10) also reported high rates of IFA consumption (86.4%) and deworming (91.6%) among school-going adolescents in tribal districts of Odisha, with smaller proportions experiencing hospitalization (1.6%), malaria (1.6%), and bloody diarrhea (2.4%). Joe et al. (2020) (23) found an increase in IFA coverage rates among school-going adolescents, (both girls (23% to 40%) and boys (21% to 42%)) and out-of-school adolescent girls (6% to 23%) across Indian states under the AMB 2017-20 strategy; with Uttarakhand reporting improvement in the index values of IFA supplementation coverage between 2017-28 (9.2%) and 2019-20 (35.3%). A mixed-method study by Sharma et al. (2024) (24) in a village in Uttar Pradesh identified unhealthy eating habits, lack of IFA supplementation, lack of proper education, absence of Anganwadi centers, intake of untreated water, and poor hygiene practices as the major causes of iron deficiency anemia in the community. This calls for an urgent need to address associated factors besides improving anemia screening and WIFS coverage. Rakesh et al. (2019) (18) also reported similar dietary trends, esp. low

intake of vitamin-C-rich foods and green leafy vegetables among anemic adolescents, highlighting the role of a balanced, nutritious diet in preventing anemia. They also reported that 12.8% of adolescents were overweight/obese and 7.2% were underweight.

Conclusion

The present study showed that out of 381 school-going adolescents residing in the rural population of a medical college in Dehradun, 39.1% screened positive for anemia using a point-of-care digital hemoglobinometer (HemoCue model No. Hb301). Three-fourths never underwent routine anemia screening under AMB. Among those who did, the majority underwent annual screening. About half gave venous samples, in private settings, and had paid for the services contrary to the recommended guidelines. Most underwent deworming in the past year but had not received prophylactic WIFS in the preceding week. Among those remaining who did, all had received tablets from govt. schools free-of-cost. Only two-thirds reported consuming blue-colored IFA tablets. Out of those adolescents enrolled in govt. schools, most underwent biannual deworming, but only one-third reported being screened for anemia, and less than one-fifth reported only consuming prophylactic IFA tablets in the preceding week.

Recommendation

Amidst the persisting burden of anemia in the rural population of a medical college in the Dehradun district, the AMB implementation strategy needs strengthening. Universal anemia screening practices among school-going adolescents using a digital hemoglobinometer with prophylactic WIFS at no cost under AMB need reinforcement for reducing the anemia burden.

Limitation of the Study

Representation of out-of-school-going adolescents from the community was not feasible due to the shorter time available for the study. The more accurate hemoglobinometer, Accusure Hb model No. HB101 could not be used due to its non-availability despite its highest sensitivity (98.3%).

Relevance of the Study

The Uttarakhand govt. is executing AMB services in all districts since 2018 to address anemia among adolescents with favourable financial support from the central govt. owing to its EAG status. Despite this, three-fourths had never undergone routine anemia screening. Those who did, about half were giving venous samples, and paying for the services in private that were otherwise supposed to be screened using a point-of-care digital hemoglobinometer in govt. or community settings at no cost to the adolescents. About 39.1% adolescents are still screening positive for anemia, with the majority not receiving WIFS. Indeed, the introspection from the present study findings reflects that AMB implementation strategy needs reinforcement in the Dehradun district.

Authors Contribution

All authors have contributed equally.

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Nil

Conflict of Interest

There are no conflicts of interest.

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Declaration of Generative AI and AI Assisted Technologies in the Writing Process

The authors haven't used any generative AI/AI assisted technologies in the writing process.

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