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Prevalence and predictors of anaemia among adolescents in India: An exploration from Understanding the Lives of Adolescents and Young Adults Survey

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Abstract

Background

Anaemia is a public health concern affecting both developed and developing countries with significant consequences for both human health as well as social and economic development. Unfortunately, the anaemia intervention program, such as the National Nutrition Anaemia Prophylaxis Programme, mostly targets infants, young children, pregnant and lactation women, and not adolescents. Therefore, this study tries to fill this gap, aimed to study the prevalence of anaemia and the associated factors among adolescent boys and girls residing in Uttar Pradesh and Bihar, India.

Methods

Secondary data analysis was performed on cross-sectional survey data from the Understanding the Lives of Adolescents and Young Adults (UDAYA) project survey. Three levels of severity of anaemia were distinguished: mild anaemia, moderate anaemia, and severe anaemia. Descriptive statistics and bivariate analysis were used to find the preliminary results. To provide the adjusted estimates for the analysis, multinomial regression analysis was carried out.

Results

Overall, a higher percentage of adolescent girls suffered from mild (42% vs. 23.7%) and moderate/severe (20% vs. 8.7%) anemia compared to the adolescent boys. Moderate/severe anemia was 0.24 and 0.49 times less likely among adolescent boys and girls, respectively, who had 10 & above years of schooling than adolescents with no schooling ($p < 0.01$). Rural adolescent boys were 1.22 ($p < 0.10$) and 1.49 times ($p < 0.05$) more likely to suffer from mild and moderate/severe anemia, respectively, compared to urban counterparts.

Conclusion

Anaemia among adolescents must be addressed through effective public health policy targeting adolescents residing in poor households and rural areas. There is a need to disseminate information about anaemia through mass media, and subsequently, the public health system may be prepared to tailor the needs of adolescent boys and girls.

Background:

Anaemia is a public health concern affecting both developed and developing countries with significant consequences for both human health as well as social and economic development[1]. It is a condition in which the number and size of red blood cells or haemoglobin concentration are lower than the established cut-off value, consequently impairing the blood's capacity to transport oxygen around the body[2]. Globally, anaemia affected 1.93 billion people in 2013, collectively causing 61.5 million years of life lived with disability (YLDs) [3], and the prevalence was highest in Africa and South-East Asia region[1]. According to WHO guidelines for the control of iron deficiency anaemia, nutritional anaemia is a major public health concern in India, primarily due to iron deficiency [4]. A population-based study shows that 28.4% of the 14,300 Indian adolescents were anaemic, and the major causes of anaemia were vitamin B12 deficiency (25.6%), iron deficiency (21.3%), dimorphic anaemia (18.2%), and anaemia of inflammation (3.4%)[5]. Moreover, small studies done among adolescents from different parts of India reported that the prevalence of anaemia was 61.5% in Gujarat, 52.5% in Madhya Pradesh, 41.1% in Karnataka,50% in Bihar, and56.3% in Uttar Pradesh[4], [6–9].

While the causes of anaemia are many, it is estimated that half of the cases are due to iron deficiency[2]. However, deficiency in the micronutrient-rich diet, Vitamin A, and Vitamin B12 could be the reason for iron deficiency [10]. Iron deficiency anemia is a condition resulting from the lack of available iron required to support normal red cell production[11]. The other important causes of anaemia are nutritional deficiency, sickle cell disease, thalassemia, bacterial infections, inadequate dietary iron intake, absorption, increased needs for iron during pregnancy, and increased menstrual iron loss [2]. It is believed that with increasing age, females are more prone to anaemia than their male counterparts [12]. When girls reach menarche and once the peak of maximum growth has been achieved, iron requirements also increase, and this situation continues until menopause. According to the estimates, about30-40 mL of blood is lost during each menstruation, leading to a loss of around 15–30 mg of iron per cycle[13]. Female adolescents need around 455 mg of iron per year after menarche, while males need 350 mg of iron per year[13]. Studies have also shown that socio-economic factors such as low economic status [14], adolescent level of education [15], housing condition, and hygiene practices[16] influence the risk of anaemia. Evidence from the population-based study on anaemia among adolescent girls shows that as the household income increased from the lowest to the highest quartile, the prevalence of anaemia and iron deficiency anaemia decreases, and the daily iron intake significantly increases with income level[17].

Adolescence is a period of physical growth, cognitive transformation, and reproductive maturation in the life cycle, which leads to the high requirements of macro or micronutrients or both [18]. During this period, they are exposed to a greater risk of iron deficiency and anaemia. This is due to rapid pubertal growth with a sharp increase in lean body mass, blood volume, and red cell mass, which increases iron needs for myoglobin in muscles and haemoglobin in the blood[19]. The overall iron requirement increases two to three times from a preadolescent level of approximately 0.7–0.9 mg iron per day to as much as 1.37–1.88 mg per day in adolescent boys and 1.40–3.27 in adolescent girls[20]. In adolescents, anemia has been linked to affecting physical disorder, development delay, and mental retardation, besides increasing reproductive morbidities among adolescent girls during their womanhood[12]. Iron deficiency anaemia reduced infection resistance, impaired physical growth and mental development, and reduced physical fitness, work capacity, and school performance [19]. Besides, when anaemic adolescent girls become pregnant, they are exposed not only to the risk of maternal morbidity and mortality but also the incidence of premature delivery, low birth weight, and perinatal mortality, and also infant born to anaemic mother have a greater risk of anaemia in the first six months of life [21].

The background mentioned above justifies the adverse effects of anaemia on adolescents and warrant further study to explore the determinants of anaemia among adolescents. Also, the existing studies on anaemia among adolescents boys and girls in Uttar Pradesh and Bihar[4], [9], [22] are based on data from a small sample that may not represent the overall study population. There are limited studies in Uttar Pradesh and Bihar regarding anaemia among adolescents using large sample data focusing on adolescent boys and girls. Hence this study tries to fill this gap to study the prevalence of anaemia and the associated factors among adolescent boys and girls residing in Uttar Pradesh and Bihar.

Methods:

Data

Secondary data analysis was performed on cross-sectional survey data from the Understanding the Lives of Adolescents and Young Adults (UDAYA) project survey. The survey was conducted in two Indian states, namely, Uttar Pradesh and Bihar, in 2016 by the Population Council under the guidance of Ministry of Health and Family Welfare, Government of India. The UDAYA collected detailed information on family, media, community environment, assets acquired in adolescence, and transitions to young adulthood indicators. Uttar Pradesh and Bihar's sample size was determined to be around 10,350 and 10,350 adolescents aged 10-19 years, respectively. The required sample for each sub-group of adolescents was determined at 920 younger boys (10-14 years), 2,350 older boys (15-19 years), 630 younger girls (10-14 years), 3,750 unmarried older girls (15-19 years), and 2,700 married girls in both states. The UDAYA adopted a multi-stage systematic sampling design to provide the estimates for states as a whole as well as urban and rural areas of the states. The detailed information on the sampling procedure and survey design was published elsewhere [23]. This study's effective sample size was 20,594 adolescents aged 10-19 years in Uttar Pradesh and Bihar. However, for anaemia measurement, only 7,876 adolescents were eligible.

Variable description:

Outcome variable

1. Three levels of severity of anaemia were distinguished: mild anaemia (10–11.4 g/dl for 10–11-year-olds, 10–11.9 g/dl for 12–14-year-olds and non-pregnant girls in ages 15–19 years, 10–10.9 g/dl for pregnant girls in ages 15–19 years, and 12–12.9 g/dl for boys in ages 15–19 years); moderate anaemia (7.0–9.9 g/dl for 10–14-year-olds and girls in ages 15–19 years, regardless of pregnancy status at the time of the interview, and 9.0–11.9 g/dl for boys in ages 15–19 years); and severe anaemia (<7.0 g/dl for 10–14-year-olds and girls in ages 15–19, regardless of pregnancy status, and <9.0 g/dl for boys in ages 15–19 years) [23]. The anaemia was coded as 0 “normal,” 1 “mild anaemia” and 2 “moderate and severe anaemia.” Moderate and severe anaemia category was

combined due to the low sample size in the severe anaemia category. The analysis was further bifurcated into adolescent boys and girls as the data provide estimates separately for both categories.

Explanatory variables

1. Age was grouped into two categories, i.e., early adolescents (10-14 years) and late adolescents (15-19 years). This study provides data for two age groups (10-14 years and 15-19 years); therefore, we have categorized age into two categories. Furthermore, previous studies have also noticed the importance of age in the studies related to anaemia among adolescents [16,24].
2. Education was recoded as no education, 1-7, 8-9, and 10 and above years of education. Previously available literature provided clear evidence of the importance of education in improving anaemia levels among adolescents [25]. Studies noted that lower educational status leads to higher anaemia levels [25].
3. Working status was recoded as not working “no” and working “yes.” Working status was defined as the respondents who did paid work in the last one year. Previous studies noted an association between working status and anaemia level [26].
4. Media exposure was coded as no exposure, rare exposure, and frequent exposure. Media exposure was formed using whether the respondent was exposed to television, radio, or newspaper. Rare media exposure was defined as those exposed to media at least once a week/month and frequent consist of those exposed to media every day. Media exposure can affect the anaemia level as exposure to mass-media leads to increased awareness, which improves anaemia levels [27].
5. Marital status was coded as “married” and “not married.” The question regarding marital status was only asked from adolescent girls aged 15-19 years. Studies are of the opinion that girls marrying during adolescence increase the risk of complications during pregnancy [28]. One such complication can be the higher level of anaemia among them [29].
6. Received Iron folic acid (IFA) and deworming tablets were coded in no and yes.
7. Body Mass Index (BMI) status was coded as “thin (BMI-for-age Z-score $< -2SD$)”, “normal (BMI-for-age Z-score $\geq -2SD$ and $\leq 1SD$” and “overweight/obese (BMI-for-age Z-score $> +1SD$)”[30].
8. Stunting was coded as “stunted” and “not stunted.” Height -for-age Z-score of $<= -2SD$ was cut-for stunting among adolescents[31].
9. The wealth index was recoded as poorest, poorer, middle, richer, and richest. The survey measured household economic status using a wealth index composed of household asset data on ownership of selected durable goods, including means of transportation, as well as data on access to several amenities. The wealth index was constructed by allocating the following scores to a household's reported assets or amenities. Then using the scores were divided into five quintiles. Previous studies noted an association between wealth index and anaemia [24,25].
10. Caste was recoded as Scheduled caste and Scheduled tribe (SC/ST), and non-SC/ST. The Scheduled Caste include “untouchables,”; a group of population that is socially segregated and

financially/economically by their low status as per Hindu caste hierarchy. The Scheduled Castes (SCs) and Scheduled Tribes (STs) are among India's most disadvantaged socio-economic groups. Previous studies also explored the possible association between caste and anaemia. [24].

11. Religion was recoded as Hindu and non-Hindu. The category of non-Hindu was recoded as so because the frequency of other religions was very low; therefore, for the analytical purpose, the recoding was done in respective manner. Religion has been noted as one of the predictors of anaemia levels in the Indian context. [24].
12. Residence was available in data as urban and rural. Previous studies also noted an association between place of residence and anaemia [24,25].

Statistical analysis

Univariate and bivariate analysis was carried out to provide the preliminary estimates. To provide the adjusted estimates for the analysis, multinomial regression analysis was carried out. Multinomial logistic regression is used to model nominal outcome variables, in which the log odds of the outcomes are modeled as a linear combination of the predictor variables. The ratio of the probability of choosing one outcome category over the probability of choosing the baseline category is often referred to as relative risk (and it is also sometimes referred to as odds, as we have just used to describe the regression parameters above). Relative risk can be obtained by exponentiation the linear equations below, yielding regression coefficients that are relative risk ratios for a unit change in the predictor variable.

$$\ln\left(\frac{P\ (Anemia =\ Mild)}{P\ (Anemia =\ Normal)}\right) =\ b_1 + b_{11}X_{11} + b_{12}X_{12} \dots\dots\dots .. b_{1n}X_{1n}$$

$$\ln\left(\frac{P\ (Anemia =\ Moderate/Severe)}{P\ (Anemia =\ Normal)}\right) =\ b_2 + b_{21}X_{21} + b_{22}X_{22} \dots\dots\dots .. b_{2n}X_{2n}$$

Where, $X_{11}, X_{12 \dots\dots} X_{1n}$ and $X_{21}, X_{22 \dots\dots} X_{2n}$ will be the explanatory variables and

$b_{11}, b_{12 \dots\dots} b_{1n}$ and $b_{21}, b_{22 \dots\dots} b_{2n}$ will be corresponding coefficients, respectively.

Results:

Figure 1 displays the prevalence of anemia among adolescent boys and girls aged 10-19 years. Overall, adolescent girls suffered more from mild (42% vs. 23.7%) and moderate/severe (20% vs. 8.7%) anemia compared to adolescent boys.

The sample distribution of the study population was presented in **Table 1**. A higher proportion of adolescents were from the late adolescent group (15-19); about one-fourth of adolescent boys and one-third of girls had 10 & above years of schooling, respectively. Nearly 27 percent of adolescent boys and 17 percent of girls were working. Three-fourth of adolescent boys and half of the girls had frequent media exposure, and 19 percent of adolescent boys and 13 percent of girls received IFA and deworming tablets. One-fourth of adolescent boys and 13 percent of girls were thin; moreover, 26 percent of adolescent boys and 39 percent of girls were stunted.

Table-1 Socio-demographic profile of adolescents aged 10-19 years				
Background characteristics	**Adolescent boys**		**Adolescent girls**	
	Sample	**Percentage**	**Sample**	**Percentage**
Age (years)				
Early adolescents (10-14)	2,084	34.9	1,653	11.3
Late adolescents (15-19)	3,885	65.1	12,972	88.7
Educational status (in years)				
No schooling	190	3.2	1,890	12.9
1-7	2,497	41.8	3,939	26.9
8-9	1,754	29.4	4,093	28.0
10 and above	1,528	25.6	4,703	32.2
Working status				
No	4,377	73.3	12,179	83.3
Yes	1,592	26.7	2,446	16.7
Media exposure				
No exposure	335	5.6	2,703	18.5
Rare	1,078	18.1	4,212	28.8
Frequent	4,555	76.3	7,710	52.7
Marital status				
Married	N.A	N.A	5,206	35.6
Unmarried	N.A	N.A	9,419	64.4
Received IFA and Deworming tablets				
No	4,856	81.4	12,780	87.4
Yes	1,113	18.7	1,845	12.6
BMI status				
Thin	837	25.8	561	13.1
Normal	2,323	71.7	3,585	83.4
Overweight/obese	81	2.5	150	3.5
Stunting status				

Not stunted	2,372	74.4	2,668	60.7
Stunted	817	25.6	1,725	39.3
Wealth index				
Poorest	704	11.8	1,971	13.5
Poorer	1,193	20.0	2,735	18.7
Middle	1,374	23.0	3,188	21.8
Richer	1,391	23.3	3,577	24.5
Richest	1,308	21.9	3,154	21.6
Caste				
SC/ST	1,605	26.9	3,784	25.9
Non-SC/ST	4,364	73.1	10,841	74.1
Religion				
Hindu	5,024	84.2	11,540	78.9
Non-Hindu	945	15.8	3,085	21.1
Residence				
Urban	1,030	17.3	2,356	16.1
Rural	4,939	82.7	12,269	83.9
States				
Uttar Pradesh	4,069	68.2	9,855	67.4
Bihar	1,900	31.8	4,770	32.6
Total	5,969	100.0	14,625	100.0
NA: Not Available; SC/ST: Scheduled Caste/Scheduled Tribe; sample is low because of anthropometric measures eligibility				

Percentage distribution of anemia among adolescent boys and girls by background characteristics were presented in **Table 2**. The prevalence of mild anemia was significantly higher among early adolescents; however, moderate/severe anemia was more prevalent among late adolescents irrespective of their gender. The prevalence of moderate/severe anemia was significantly higher among adolescents with no schooling (boy-11.7% and girl-28.7%), and it was significantly lower among adolescents who had 10 & above years of schooling (boy-6.1% and girl-19.3%). A higher percentage of working adolescents (boy-13.2% and girl-23.4%) suffered from moderate/severe anemia compared to not working. Moreover, media exposure has a negative association with mild and moderate/severe anemia among adolescent boys. The prevalence of mild anemia was more among unmarried adolescent girls (44.4%), and moderate/severe anemia was more prevalent among married adolescent girls (26.2%). Adolescents who received IFA and deworming tablets (boy-6.1% and girl-16.1%) suffered less from moderate/severe anemia than those who did not receive, irrespective of their gender. Stunted adolescent boys suffered more from mild (29.5%) or moderate/severe (11.2%) anemia than those who were not stunted. A similar result was found for adolescent girls though it was not significant. The prevalence of mild or moderate/severe anemia was significantly higher among the poorest adolescents, and it was lowest among the richest ones, irrespective of their gender. Moreover, moderate/severe anemia was more prevalent among SC/ST adolescents (boy-9.4% and girl-23.7%), and rural adolescents suffered more from moderate/severe anemia (boy-9.2% and girl-20%) than urban counterparts.

Table-2 Percentage distribution of anemia among adolescents boys and girls by background characteristics						
Background characteristics	**Adolescent boys (N=3,186)**			**Adolescent girls (N=4,690)**		
	Mild (%)	**Moderate/Severe (%)**	**p<0.05**	**Mild (%)**	**Moderate/Severe (%)**	**p<0.05**
Age (years)			*			*
Early adolescents (10-14)	27.1	6.5		42.6	12.6	
Late adolescents (15-19)	18.7	11.9		41.7	23.6	
Educational status (in years)			*			*
No schooling	16.8	11.7		39.3	28.7	
1-7	27.0	8.3		40.9	16.9	
8-9	20.9	11.1		44.4	21.1	
10 and above	16.5	6.1		42.7	19.3	
Working status			*			*
No	23.7	7.5		41.8	19.5	
Yes	23.4	13.2		42.9	23.4	
Media exposure			*			*
No exposure	28.4	13.1		44.1	26.1	
Rare	25.1	7.8		40.2	18.0	
Frequent	22.9	8.6		42.2	18.9	
Marital status						*
Married	N.A	N.A		38.8	26.2	
Unmarried	N.A	N.A		44.4	15.3	
Received IFA and Deworming tablets			*			*
No	23.7	9.5		40.8	20.7	
Yes	23.7	6.1		49.0	16.1	
BMI status			*			
Thin	27.8	7.4		43.6	12.3	

Normal	22.8	9.5		44.2	18.4	
Overweight/obese	4.4	0.5		38.8	24.7	
Stunting status			*			
Not stunted	21.7	7.9		41.6	19.8	
Stunted	29.5	11.2		42.4	20.2	
Wealth index			*			*
Poorest	33.1	8.5		42.8	20.2	
Poorer	25.1	8.7		43.7	20.5	
Middle	20.9	9.2		43.0	19.9	
Richer	22.9	9.2		41.3	18.3	
Richest	20.2	7.8		39.2	21.7	
Caste			*			*
SC/ST	28.0	9.4		39.8	23.7	
Non-SC/ST	22.1	8.4		42.8	18.6	
Religion			*			*
Hindu	24.8	9.2		42.6	20.3	
Non-Hindu	17.4	5.8		39.6	18.6	
Residence			*			
Urban	19.3	5.9		43.5	19.9	
Rural	24.5	9.2		41.7	20.0	
States			*			*
Uttar Pradesh	25.2	10.5		39.6	21.7	
Bihar	20.6	5.1		46.3	17.0	
SC/ST: Scheduled Caste/Scheduled Tribe; *if p<0.05; NA: Not Available						

Relative risk ratios (RRRs) obtained from multinomial logistic regression identified plausible correlates of anemia among adolescent boys and girls (**Table 3**). The likelihood of mild anemia was 0.73 times ($p<0.05$) less likely, and moderate/severe anemia was 3.68 times ($p<0.01$) more likely among late adolescent boys compared to early adolescent boys. Moreover, late-adolescent girls were 1.32 ($p<0.05$) and 1.87 ($p<0.01$) times more likely to suffer from mild and moderate/severe anemia, respectively, than early adolescent girls. Moderate/severe anemia was 0.24and 0.49 times less likely among adolescent boys and girls, respectively, who had 10 & above years of schooling than adolescents with no schooling (p<0.01). Adolescent boys who had rare and frequent media exposure were 0.56 (p<0.10) and 0.49 times (p<0.05) less likely to suffer from moderate/severe anemia, respectively, than those who had no exposure. A similar result was observed for adolescent girls who had rare and frequent media exposure. Surprisingly, mild anemia was 1.25 (p<0.05) times more likely among adolescent girls who received IFA and deworming tablets than those who were not received. Overweight/obese adolescent boys were 0.24 (p<0.01) and 0.29 times (p<0.10) less likely to suffer from mild and moderate/severe anemia, respectively, than those who had normal BMI. The likelihood of mild and moderate/severe anemia was 1.51 and 1.64 times more likely among stunted adolescent boys than those who were not stunted (p<0.01). However, adolescent girls who were stunted were 0.87 and 0.84 times less likely to suffer from mild and moderate/severe anemia than those who were not stunted (p<0.10). Rural adolescent boys were 1.22 (p<0.10) and 1.49 times (p<0.05) more likely to suffer from mild and moderate/severe anemia, respectively, compared to urban counterparts. Moreover, rural adolescent girls were 0.77 times (p<0.01) less likely to suffer from mild anemia than urban girls.

Table 3: Relative risk ratios (RRRs) obtained from multinomial logistic regression of anemia among adolescents bybackground characteristics, India				
Background characteristics	**Adolescent boys (N=3,186)**		**Adolescent girls (N=4,690)**	
	Mild	**Moderate/Severe**	**Mild**	**Moderate/Severe**
	RRR (CI)	**RRR (CI)**	**RRR (CI)**	**RRR (CI)**
Age (years)				
Early adolescents (10-14) **(Ref.)**				
Late adolescents (15-19)	0.73**(0.55 -0.97)	3.68***(2.45 -5.53)	1.32**(1.06 -1.64)	1.87***(1.4 -2.5)
Educational status (in years)				
No schooling**(Ref.)**				
1-7	0.81(0.46 -1.42)	0.78(0.36 -1.69)	0.97(0.74 -1.27)	0.70**(0.51 -0.98)
8-9	0.70(0.39 -1.25)	0.55(0.25 -1.22)	1.08(0.82 -1.43)	0.71**(0.51 -1)
10 and above	0.43**(0.23 -0.82)	0.24***(0.1 -0.56)	0.93(0.69 -1.25)	0.49***(0.34 -0.72)
Working status				
No**(Ref.)**				
Yes	0.92(0.7 -1.21)	0.80(0.54 -1.19)	0.96(0.76 -1.21)	1.07(0.8 -1.44)
Media exposure				
No exposure**(Ref.)**				
Rare	0.85(0.54 -1.32)	0.56*(0.29 -1.09)	0.71***(0.56 -0.89)	0.75*(0.55 -1.01)
Frequent	0.78(0.51 -1.18)	0.49**(0.27 -0.9)	0.69***(0.54 -0.87)	0.75*(0.55 -1.03)
Marital status				
Married**(Ref.)**	N.A.	N.A.		
Unmarried	N.A.	N.A.	0.90(0.74 -1.1)	0.84(0.66 -1.08)
Received IFA and Deworming tablets				

No**(Ref.)**				
Yes	1.04(0.82 -1.31)	0.90(0.59 -1.37)	1.25**(1.02 -1.52)	1.06(0.80 -1.41)
BMI status				
Thin	1.01(0.82 -1.25)	1.08(0.77 -1.52)	0.94(0.76 -1.17)	0.80(0.59 -1.07)
Normal**(Ref.)**				
Overweight/obese	0.24***(0.10 -0.55)	0.29*(0.07 -1.22)	0.92(0.63 -1.32)	0.78(0.46 -1.30)
Stunting status				
Not stunted**(Ref.)**				
Stunted	1.51***(1.23 -1.87)	1.64***(1.18 -2.28)	0.87*(0.75 -1.01)	0.84*(0.69 -1.02)
Wealth				
Poorest**(Ref.)**				
Poorer	0.69**(0.5 -0.95)	0.71(0.41 -1.22)	1.0(0.77 -1.29)	1.0(0.71 -1.41)
Middle	0.66**(0.48 -0.91)	0.86(0.52 -1.44)	1.05(0.81 -1.35)	1.13(0.81 -1.58)
Richer	0.86(0.62 -1.19)	0.79(0.46 -1.37)	0.97(0.74 -1.26)	0.86(0.60 -1.22)
Richest	0.73*(0.52 -1.04)	0.80(0.44 -1.43)	0.85(0.64 -1.14)	1.06(0.72 -1.56)
Caste				
SC/ST**(Ref.)**				
Non-SC/ST	0.92(0.74 -1.14)	1.08(0.76 -1.55)	1.03(0.86 -1.23)	0.84(0.67 -1.06)
Religion				
Hindu**(Ref.)**				
Non-Hindu	0.70**(0.54 -0.92)	0.60**(0.38 -0.95)	0.82**(0.68 -0.99)	0.77**(0.6 -1)
Residence				
Urban**(Ref.)**				
Rural	1.22*(0.99 -1.5)	1.49**(1.05 -2.11)	0.77***(0.66 -0.91)	0.85(0.68 -1.06)

States				
Uttar Pradesh**(Ref.)**				
Bihar	0.67***(0.55 -0.82)	0.45***(0.32 -0.63)	1.11(0.95 -1.29)	0.77**(0.63 -0.94)
RRR = Relative risk ratio; CI = Confidence interval; Ref. Reference; ***p < 0.001; **p < 0.05; *p < 0.10; base category = 'not anemic'; SC/ST: Scheduled Caste/Scheduled Tribe; NA: Not Available.				

Discussion:

This study aimed at examining the prevalence and associated factors of anaemia among adolescents, separately for male and female adolescents. Previously several studies have examined prevalence and factors associated with anaemia; however, most of the available literature is limited to female adolescents, thus ignoring male adolescents [14], [32-34]. Furthermore, most of the available literature was limited to community study with a limited sample size [14, 32-36]. Most of the study examined prevalence and factors associated with anaemia among adolescents aged 10-14 years or 15-19 years, thus missing out on a comprehensive analysis of adolescents aged 10-19 years [6], [37]. A study examined anaemia among adolescents aged 10-18 years [38]. Minimal literature was available examining anaemia among male and female adolescents aged 10-19 years [12]. This study found that around one-fourth (23.7%) of the adolescent boys and 42 percent of the adolescent girls had mild anaemia. In contrast, around 9 percent of the adolescent boys and one-fifth (20%) adolescent girls were moderate and severely anaemic. The prevalence of anaemia found in this study is somewhat similar to a previous study [12]. Furthermore, the study found that around 19 percent of the late adolescent boys (15-19 years) and 42 percent of the late adolescent girls had mild anaemia. Mahajan et al., in their study on adolescent boys and girls aged 14-18 years, noticed the prevalence of anaemia of around 45 percent among adolescent girls and 16 percent among adolescent boys [6].

The study found that anaemia was a severe concern among adolescent girls than in adolescent boys. A higher percentage of adolescent girls had severe anaemia than adolescent boys. This could be because of the onset of the menstrual cycle among girls that prompts physiological blood loss among them [12], [16]. Furthermore, severe anaemia among late adolescent girls was higher than in early adolescent girls. Girls in late adolescence may get married by the time and become pregnant, which may further affect their anaemia status [39]. Furthermore, adolescents have increased nutritional demands during a period of rapid growth, and this may justify why late adolescents have poor anaemia status than early adolescents [40]. In the Indian context, boys tend to consume more nutritious food than girls [41], and nutritious food is known to improve anaemia levels among adolescents [42]. Another study also noted that Indian females consume nutrient-rich foods less frequently than Indian males and were twice likely to suffer from anaemia as their male counterparts [43].

The study noticed a negative association between education and anaemia status among adolescents; increasing years of education among adolescents decreased the risk of anaemia. Previous studies have also acknowledged the importance of education in reducing the risk of anaemia among adolescents [14]. Not only adolescent's education but studies have also noted the importance of parent's education in reducing anaemia among adolescents [44]. Educated adolescents are well-informed about their nutrition choices, which may be attributed to their improved anaemia levels. Education-based health belief model was found to be effective in promoting knowledge, attitude, and behaviour in preventing anaemia [45]. Specifically, among girls, education improves the IFA tablet intake that further improves their anaemia level [46]. Education is a tool to combat anaemia as it effectively promotes health and nutritional knowledge among adolescents [47].

Media exposure was another significant predictor of anaemia among adolescents; frequent media exposure among adolescents was noticed as a safety net against anaemia. It is interesting to note that adolescents exposed to any sort of media were significantly less likely to be anaemic even after controlling other variables. Media exposure positively influences dietary intake, which may be attributed to reducing anaemia [48]. Arguably, exposure to mass media can play an important role in enhancing knowledge on safe health practices and behaviour, and eating a proper diet rich in essential nutrients and iron, among other things; all these further lead to an improvement in anaemia levels [49].

Wealth was negatively associated with the risk of anaemia among male adolescents. Higher wealth was associated with a reduced risk of anaemia. Previously available literature also noticed that increased household wealth reduces the risk of anaemia among adolescents [15], [50]. Children belonging to rich households tend to have improved nutritional status, which may be attributed to better anaemia levels than their counterparts in poor households [24]. Adolescents from poor households consume less diversified diets with poor micronutrients, resulting in higher anaemia among adolescents [50]. As stated above, a boy tends to consume more nutritious food than girls; thus, male adolescents had a lower risk of anaemia than their counterparts. However, it is to be seen how household wealth disintegrates boy and girl for anaemia, and to seek the answer, and we suggest more such studies shall be undertaken. The prevalence of anaemia was higher among rural adolescents than their counterparts in urban areas. Previous studies also noted rural-urban differences in anaemia and found that severe anaemia prevalence was higher among respondents in rural areas than in urban areas [51-52]. In rural areas, girls generally get married at an early age and become pregnant during the late adolescent period, thus increasing the risk of anaemia [39]. Poor accessibility to healthcare services, poor awareness, high poverty, and illiteracy in rural areas may be attributed to the poor anaemia levels among children in rural areas [52]. Furthermore, poor nutritional status in rural areas may also be attributed to the higher anaemia among children in rural areas [52].

Strengths And Limitations:

The data is cross-sectional. Therefore, we could not establish causality between predictors and anaemia status among adolescent boys and girls; however, our study contributes to the limited available literature in this understudied population group. Furthermore, the data is not pan-India and is limited to only two socio-economic backward states of India; therefore, findings shall not be generalized to the country population. However, this is also one of the potential strengths of the study. Data were collected from Uttar and Bihar, and these two states have the highest adolescent population in India; therefore, the study is very important.

Conclusion:

The prevalence of anaemia among adolescent boys and girls in the study area is a public health concern. The study noticed that the prevalence of anaemia was higher among female adolescents than in male adolescents. Furthermore, severe anaemia was higher among late adolescents, adolescents without schooling, adolescents without media exposure, and rural adolescents. Strategies to improve iron status among adolescent boys and girls might reduce anaemia among adolescents [15]. However, in our study, the association between IFA tablets and anaemia among female adolescents was not on the expected lines. Anaemia among adolescents must be addressed through effective public health policy targeting adolescents residing in poor households and rural areas. There is a need to disseminate information about anaemia through mass media, and subsequently, the public health system may be prepared to tailor the needs of adolescent boys and girls. Appropriate Behavioural Change Communication (BCC) interventions are required in rural areas to cater to rural adolescents' needs.

Abbreviations

BMI: Body Mass Index

IFA: Iron-folic Acid

RRR: Relative Risk Ratio

SC: Scheduled Caste

SD: Standard Deviation

ST: Scheduled Tribe

UDAYA: Understanding the Lives of Adolescents and Young Adults

Declarations

Ethics approval and consent to participate: The data is freely available in public domain and survey agencies that conducted the field survey for the data collection have collected a prior consent from the respondent. The data can be accessed from: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/RRXQNT

Consent for publication: Not applicable

Availability of data and materials: The study utilises secondary source of data which is freely available in public domain through https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/RRXQNT. The necessary ethical approval has been taken by the respective organisations involved in the data collection process.

Competing Interest: The authors declare that they have no competing interests.

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Author's Contribution: The concept was drafted by SS, PK, SC, and RP. SS and PK contributed to the analysis design. SC advised on the paper and assisted in paper conceptualization. SC, RP, and SPM contributed in the comprehensive writing of the article. All authors read and approved the final manuscript.

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Figures

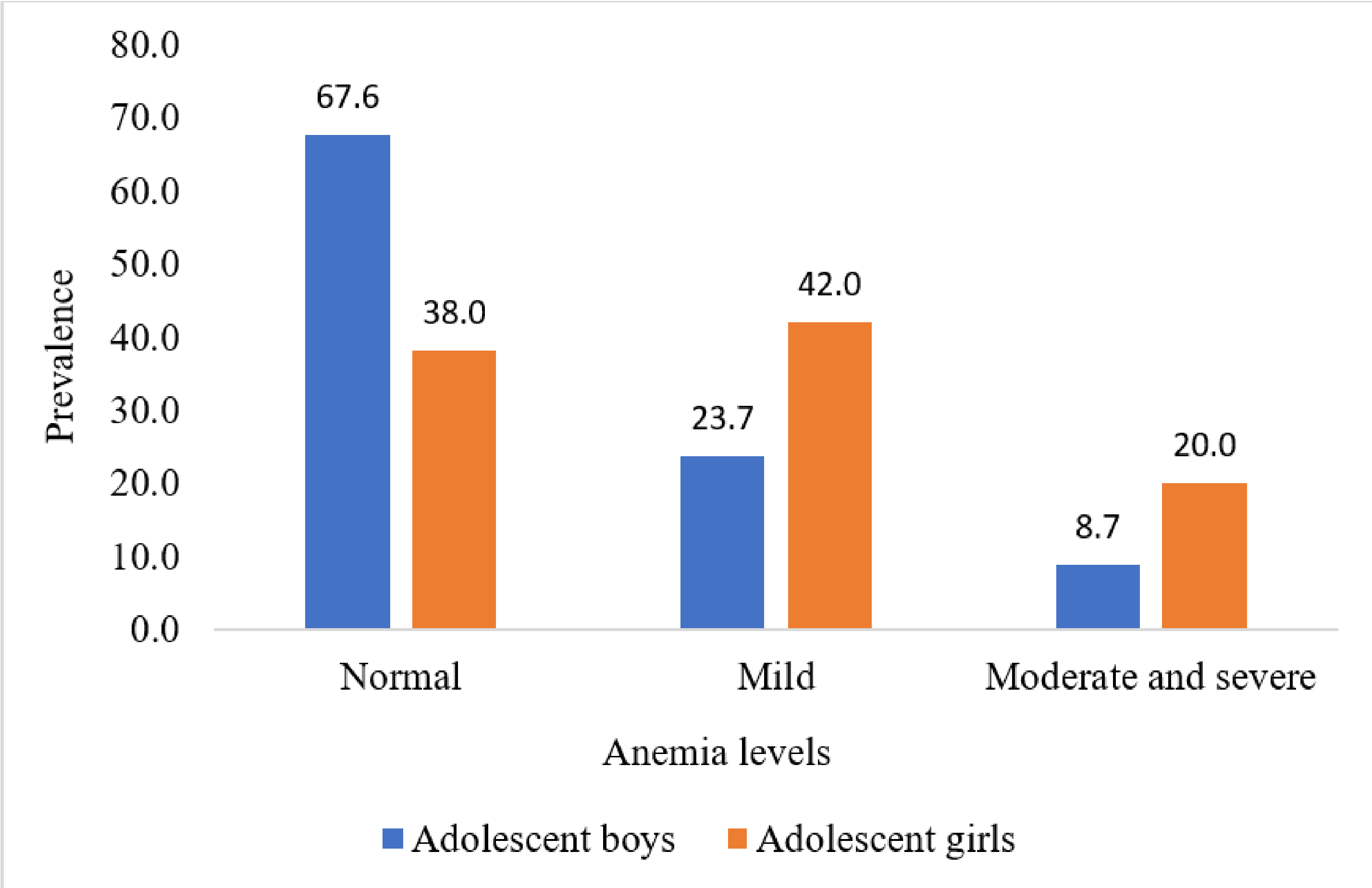

Figure 1

Prevalence of anemia among adolescent boys and girls Legend: Adolescent boys, adolescent girls