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Nutritional Status and Anemia among Scheduled Caste Adolescent Girls of District Yamunanagar, Haryana, India

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ABSTRACT

Background: During adolescence, nutrition is crucial for physical and cognitive development, yet socio-economic disparities and nutritional deficiencies, especially in girls, lead to health vulnerabilities, including high anemia rates. Despite recent data from the National Family Health Survey, there is limited information on adolescents aged 11-16 years, requiring targeted research. This cross-sectional study aims to assess the nutritional status, determine the prevalence of anemia, and explore associated factors among adolescent girls of the scheduled caste in District Yamunanagar, Haryana, India.

Methods: The study sampled 450 scheduled caste girls aged 11-16 years from schools in District Yamunanagar, Haryana. Height and weight were measured to calculate Body Mass Index (BMI). Data on micro-environmental factors, socio-economic and demographic variables, and dietary habits were collected through interview-based schedule. Hemoglobin levels were measured using Sahli's Acid Haematin technique, and nutritional status was assessed using the World Health Organization (WHO) standards (Z-score method).

Results: The study found increases in height, weight, and BMI with age, with notable spurts at 12-13 years for height and 11-12 years for weight and BMI. Significant differences in height, weight, and BMI were observed between age groups. Moreover, 92.2% girls were found to be anemic, with most of them suffering from moderate anemia. Additionally, the prevalence of stunting was 67.33% and wasting was 64.90% among the girls. Household size, number of family members and menarcheal status of the girls showed a significant association with the nutritional status and anemic of the girls.

Conclusion: The study emphasizes the need of regular screening and timely interventions to improve the nutritional and anemic status of adolescent girls.

Keywords: Body Mass Index, Anemia, Nutritional Status, Hemoglobin, Adolescence

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Introduction

Adolescence marks a pivotal phase characterized by significant biological changes, encompassing significant increases in various morphological and physiological parameters. The critical importance of proper nutrition during this critical period cannot be overstated, as it addresses deficits from childhood and supports the demands of physical, cognitive growth, and development (Rani et al., 2018; Garzón et al., 2023). Adequate nutritional intake not only prevents nutrition-related diseases in adulthood but also plays a crucial role in mitigating health challenges faced by adolescents, particularly in regions with distinct socio-economic conditions (WHO, 2006; Pasricha & Biggs, 2010; Benedict et al., 2018; Rahman et al., 2023).

Anaemia affects about one in four people aged 10–24 worldwide, with the highest rates found in low- and middle-income countries (Azzopardi et al., 2019). India has one of the largest groups of young people in the world, with 253 million adolescents aged 10–19 (Scott et al., 2022). Adolescents especially girls are the main contributors to the anemia statistics than adults (Aguayo and Paintal, 2017). In India, adolescent girls encounter formidable health issues stemming from socio-economic disparities, nutritional inadequacies, and gender-based discrimination. A substantial proportion of girls in the country grapple with either general or specific health challenges, intensifying their vulnerabilities due to heightened nutritional demands (Balasubramaniam, 2005; Daniel et al., 2023). The causes of undernutrition are multifaceted, involving genetic, environmental, social, and cultural factors (Claessens et al., 2000; Burniat et al., 2006; Blossner et al., 2005). In addition, undernutrition can result from insufficient diet and recurrent severe infections, which are closely tied to overall living standards, environmental conditions, and access to essentials like food, housing, and healthcare. The unique physiological changes experienced by adolescent girls, such as an increase in lean body mass, expanded blood volume, and the onset of menstruation, elevate their nutritional requirements, rendering them susceptible to deficiencies, particularly iron deficiency leading to anemia (UNICEF, 2011). Also, anemia and undernutrition during adolescence poses severe threats to physical and mental development, impairs behavioural and cognitive functions, diminishes physical fitness, and contributes to adverse pregnancy outcomes. The elevated prevalence of anemia not only elevates the risks of maternal and child mortality but also perpetuates the intergenerational cycle of malnutrition (UNICEF, 2011; ACC/SCN, 1997; McGuire & Lopez, 2002; UNICEF, 2003; Blossner et al., 2005). Due to gender and social conditioning, girls are particularly vulnerable to poor nutritional status, leading to chronic anemia, miscarriages, and an increased likelihood of delivering low birth weight babies (Gibson et al., 2020).

The Government of India has implemented several flagship schemes and programs to address the nutritional concerns of adolescent girls, including anaemia (Mukt Bharat and POSHAN Abhiyaan). Numerous studies have been conducted in various states of India, such as those by Pattnaik et al., 2013; Subramanian et al. ,2022; Gupta et al., 2022 Nair & Doibale ,2023, to monitor the prevalence of anemia and the nutritional status of adolescent girls, especially those in rural areas, and to assess the impact of these measures.

However, there is limited research focusing on community or caste-specific assessments of these parameters in adolescent girls. Targeted interventions are crucial, since many dietary and personal habits are influenced by the community from which the girls come. Additionally, despite recent data on nutritional status and anemia from National Family Health Survey-5 (2020-2021) for the state of Haryana, there is limited information on adolescents aged 11-16 years. The findings reveal a persistent high prevalence of anemia among adolescent girls (15-19 years) in the state of Haryana, India emphasizing the need for a comprehensive approach to address this issue (NFHS-5).

Therefore, recognizing the pressing need to enhance our understanding of the nutritional and

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anaemic status among a specific demographic, the present study focused on scheduled caste adolescent girls (aged 11 to 16 years) in District Yamunanagar, Haryana, India. There is limited nationally representative nutrition survey data for this age group in the state of Haryana, India. The National Family Health Surveys (NFHS) only cover the 15-19 age group with limited nutrition indicators.

Thus, this cross-sectional study aimed to evaluate the nutritional status, estimate the prevalence of anemia, and explore correlates associated with both anemia and nutritional status among the scheduled caste adolescent girls of Haryana. By shedding light on these aspects, this paper endeavours to contribute valuable insights towards addressing the challenges faced by adolescent girls in this region and formulating targeted interventions for their holistic well-being.

Methods

District Yamunanagar, located in the state of Haryana, is one of its 21 districts, covering an area of 1756 km². It shares borders with Himachal Pradesh to the north, Uttar Pradesh to the east, District Karnal to the south, District Kurukshetra to the south-west, and District Ambala to the west. The district comprises three tehsils (Jagadhri, Chhachhrauli, and Bilaspur) and three sub-tehsils (Radaur, Sadhaura, and Mustafabad), with 475 Panchayats and 636 villages, Yamunanagar is the largest district in terms of villages in the state of Haryana, India. This study focuses on adolescent girls belonging to scheduled castes in Yamunanagar, Haryana. Scheduled castes, previously known as "depressed classes" during British rule, are population groups recognized by the Indian Constitution. Thirty-nine groups in Haryana are classified as scheduled castes under Article 341 of the constitution. Yamunanagar ranks fourth in terms of scheduled caste population among Haryana districts, with the 2011 census reporting that scheduled castes constitute 25.26% of the total population in the district. Predominant scheduled caste populations in the area include Balmiki, Chamar, and Deha.

Before starting the study, permissions for data collection from various schools in Yamunanagar district was obtained from the Chief Medical Officer (CMO) and District Education Officer (DEO). The list of all public and government schools was acquired from the District Education Office. Government schools, which had a higher percentage of enrolled scheduled caste children compared to private or public schools, were prioritized. The study purpose and methodology were explained to the principals of these government schools, and permission was obtained from the DEO, CMO, and school principals. Subsequently, data were collected from the schools. The date of birth of each girl was recorded from the school registers and all doubtful cases were excluded. The ages were converted to decimal age using 'Decimal Age Calendar' (Tanner et al., 1966). The data were divided into six age groups, each with a magnitude of one year. Each age group included all girls not more than six months older or 6 months younger than the age assigned to the group.

The subjects selected for the study were Scheduled Caste by origin. Ethical clearance for the collection of data on blood samples, anthropometric and physiological measurements on human subjects was obtained from the Ethical Review Committee of Panjab University, Chandigarh, India vide letter no. PU/IEC/97-1/13/11 dt 13/11/13. A prior written consent was obtained from the parents of the subjects after explaining the objective and methodology of the study. Each subject was also briefed about the purpose of the study before data collection. They were also made aware of the prevalence of anemia in the adolescent phase, its causal factors and dreadful consequences. All the scheduled caste girls between 11 and 16 years were included in the study. Care was taken to include apparently healthy, normal and unrelated individuals. The girls below 11 and above 16 years were excluded from the study. Those subjects who were suffering from any ailments during the last six months or had chronic systemic disease or physical disorders were also excluded. Girls who were not

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interested to participate in the study were not included in the study.

In total, 450 scheduled caste adolescent girls aged 11 to 16 years were selected for the study using purposive sampling method. For calculating the sample size (n), random sampling method was used with a 95% confidence level and a 5% margin of error (ε). Assuming a population proportion (p̂) of 0.5 and an unlimited population size, the Z-score (z) for a 95% confidence level is 1.96. The formula used was $\mathbf{n} = \mathbf{z}^2 \times \hat{\mathbf{p}} (1- \hat{\mathbf{p}})/ \boldsymbol{\varepsilon}^2$. This resulted in a sample size of 384.16. Consequently, data were collected from more than 385 subjects, who were then grouped into various age-based sub-groups. Height and weight measurements were taken using standardized anthropometric techniques (Weiner and Lourie, 1981). There was no inter-observer technical error of measurement as all the measurements were taken by the same investigator, the first author. Checks were conducted to determine intra observer technical error of measurement which was found to be less than 1%. Body mass index (BMI) was calculated, and nutritional status was assessed as z-scores using World Health Organization (WHO) (2007) reference standards. The cut-off point for undernourished girls was taken as -2 S.D. scores below the reference median. Stunting was assessed by <-2 HAZ (z-score for height-for-age) and wasting was measured by <-2 BAZ (z-score for BMI-for-age). Hemoglobin levels were estimated using Sahli's Acid Haematin method. The prevalence of anemia was evaluated using classification given by WHO (1968). Socio-economic, demographic, and micro-environmental information, along with dietary habits, were obtained using an interview-based schedule. The personal information such as caste, sub-caste, and family composition, place of birth, educational status, occupational status, and household income was taken from all the girls under study. Age at menarche was collected using the status quo method. Demographic and household attributes were evaluated using information on family composition, household size, birth order, sibship size, type of possession, duration of stay in the house, and number of rooms in the household. Micro-environmental factors, including the location of the kitchen, stove and fuel type used, presence of a chimney, location and number of toilets, drainage system, and source and adequacy of drinking water supply to the household, were also studied. The frequency of consumption of milk, fruits, mineral/vitamin supplements, non-vegetarian food, and fast food was investigated. Subjects were asked about the duration of sleep, type and duration of games played, and mode of transport used to reach school, to assess the level of physical activity. The interview-based schedule was pretested on a subset of the intended population and necessary changes were made to the schedule to get maximum information from the subjects. Socio-economic status was evaluated using a modified Kuppuswamy's socioeconomic status scale. Linear regression analysis was conducted to assess predictors of hemoglobin. One-way analysis of variance (ANOVA) was performed for each variable to study age trends. Pearson's correlation coefficient was used to evaluate the relationship between height, weight, BMI, and hemoglobin. Pearson's chi-square test was used to investigate various correlates of nutritional and anemic status. The threshold of statistical significance used for various tests was a p-value of 0.05. The statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) v. 16.

Results

As per Kuppuswamy's socioeconomic status scale, the majority of the subjects under study belonged to the upper-lower socio-economic class. The parents were largely illiterate and earned their livelihoods through low-paying daily wage labor. The mothers were primarily homemakers and did not significantly contribute to the family income. The girls under study were living in poor environmental conditions and majorly belonged to nuclear families.

Means, standard deviations, and ANOVA for

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height, weight, BMI and haemoglobin of scheduled caste adolescent girls by age are presented in Table 1. The height, weight, and BMI showed an increasing trend with advancing age among adolescent girls. The girls of the present study attained a maximum gain in stature between 12 and 13 years (6.51 cm). The minimum gain of weight (4.14 Kg) was observed between 11 and 12 years. BMI showed an increasing trend with advancing age with a maximum gain of 1.13 kg/m^2 between 11 to 12 years. A general increase in mean values for haemoglobin level was seen with advancing age except for 14 years where a decrease of 0.18 g/dl was witnessed. ANOVA revealed significant differences between age groups for height, weight, and BMI ($p < 0.05$)(Table 1).

Table 1. Descriptive statistics for height, weight, BMI and hemoglobin level of adolescent scheduled caste girls of Yamunanagar district by age

Age groups / Variables	11 Years Mean ±S.D.	12 Years Mean± S.D.	13 Years Mean± S.D.	14 Years Mean± S.D.	15 Years Mean± S.D.	16 Years Mean± S.D.	ANOVA F-value (p-value)
Height (cm)	135.54 ± 7.48	140.21 ± 7.24	146.72 ± 6.19	150.05 ± 5.83	151.00 ± 6.71	151.77 ± 5.03	78.163 (.000**)
Weight (Kg)	26.68 ± 5.30	30.82 ± 6.57	34.78 ± 6.27	38.23 ± 6.55	39.03 ± 5.11	39.89 ± 5.79	57.896 (.000**)
BMI (Kg/m^2)	14.43 ± 2.03	15.56 ± 2.40	16.09 ± 2.39	16.91 ± 2.25	17.11 ± 1.98	17.29 ± 2.24	18.429 (.000**)
Hemoglobin (g/dl)	9.9 ± 1.27	10.07 ± 1.09	10.13 ± 1.04	9.95 ± 1.13	9.98 ± 1.23	10.13 ± 1.25	0.439 (.821)

*Level of significance at p-value < 0.05, **< 0.01

Table 2 shows that majority of girls have z-scores -1 S.D. or more below the reference median indicating a considerable degree of malnutrition (Table2).

Table 2. Prevalence of stunting (height-for-age z-score) and wasting (BMI-for-age z-score) among scheduled caste girls according to the WHO, 2007

Age (Years)	Number of subjects	Normal >-1 SD		Mild -1 to -1.9 SD		Moderate -2 to -2.9 SD		Severe -3 and less	
		Stunting N (%)	Wasting N (%)	Stunting N (%)	Wasting N (%)	Stunting N (%)	Wasting N (%)	Stunting N (%)	Wasting N (%)
11	75	30 (40.00)	24 (32.00)	28 (37.30)	17 (22.70)	11 (14.70)	22 (29.30)	6 (8.00)	12 (16.00)
12	75	20 (26.70)	26 (34.70)	31 (41.30)	24 (32.00)	19 (25.30)	17 (22.70)	5 (6.70)	8 (10.70)
13	75	34 (45.30)	28 (37.30)	24 (32.00)	21 (28.00)	14 (18.70)	13 (17.30)	3 (4.00)	13 (17.30)
14	75	25 (33.30)	30 (40.00)	33 (44.00)	26 (34.70)	16 (21.30)	16 (21.30)	1 (1.30)	3 (4.00)
15	75	23 (30.70)	28 (37.30)	31 (41.30)	23 (30.70)	15 (20.00)	20 (26.70)	6 (8.00)	4 (5.30)
16	75	15 (20.00)	22 (29.30)	39 (52.00)	26 (34.70)	18 (24.00)	22 (29.30)	3 (4.00)	5 (6.70)
Total	450	147 (32.70)	158 (35.10)	186 (41.30)	137 (30.40)	93 (20.70)	110 (24.40)	24 (5.30)	45 (10.00)

Normality was assessed using the Kolmogorov-Smirnov test, indicating no evident violation. Table 3 displays age-specific correlation coefficients between height, weight, BMI, and haemoglobin in adolescent scheduled caste girls from Haryana. Height and weight exhibit a significant association, supported by the pooled correlation coefficient (r). BMI correlates significantly with height and weight. Height alone significantly associates with haemoglobin levels (Table3).

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Table 3. Correlation matrix of height, weight, BMI and haemoglobin level of adolescent scheduled caste girls of Yamunanagar district

Age groups variables	11 Years	12 Years	13 Years	14 Years	15 Years	16 Years	Total
HEIGHT							
Weight	0.695 (.000**)	0.708 (.000**)	0.606 (.000**)	0.640 (.000**)	0.533 (.000**)	0.474 (.000**)	0.775 (.000**)
BMI	0.210 (.071)	.330 (.004**)	.175 (.133)	.230 (.048*)	-0.136 (.246)	0.019 (.872)	0.379 (.000**)
Haemoglobin	0.174 (0.134)	0.188 (.107)	0.045 (.699)	.007 (.951)	.037 (.751)	.211 (.069)	.096 (0.041*)
WEIGHT							
BMI	0.843 (.000**)	.897 (.000**)	.886 (.000**)	.893 (.000**)	.761 (.000**)	0.888 (.000**)	0.873 (.000**)
Haemoglobin	0.024 (.841)	.116 (.320)	-0.053 (.652)	.025 (.830)	.117 (.319)	.085 (.470)	0.053 (.259)
BMI							
Haemoglobin	-0.073 (.536)	0.023 (.843)	-0.099 (.400)	0.036 (.762)	.106 (.367)	-0.012 (.922)	0.006 (.905)

*Level of significance at p-value < 0.05, **< 0.01

Table 4 presents values of adjusted R^2 (with p-values) from linear regression predicting haemoglobin levels from height, weight, and BMI in adolescent girls of Haryana. Height predicted a variance of 0.7% in hemoglobin level, thus making it the best predictor of hemoglobin level as compared to weight and BMI among adolescent scheduled caste girls (Table4).

Table 4. Adjusted R2 (with p-values) from linear regression predicting Haemoglobin level from height, weight and BMI in adolescent scheduled caste girls of Yamunanagar, Haryana

	Height	Weight	BMI
		Hemoglobin	
Girls (n=450)	Adj R^2 (p value) 0.007 (0.041)*	Adj R^2 (p value) 0.001 (0.259)	Adj R^2 (p value) -0.002 (0.905)

*Level of significance at p-value < 0.05

Table 5 presents the age-wise prevalence of different grades of anemia among the adolescent girls of Haryana. Majority of the girls were found to be suffering from various grades of anemia (Table5).

Table 5. Prevalence of different grades of anemia in adolescent scheduled caste girls of Yamunanagar district

Age groups (Years)	N	Severe anemia (upto 7g/dl)		Moderate anemia (7-10 g/dl)		Mild anemia (10-12 g/dl)		Normal (12g/dl and above)	
		N	%	N	%	N	%	N	%
11	75	3	4.00	53	70.70	6	8.00	13	17.30
12	75	2	2.70	54	72.00	15	20.00	4	5.30
13	75	3	4.00	50	66.70	20	26.70	2	2.70
14	75	4	5.30	59	78.70	8	10.70	4	5.30
15	75	4	5.30	47	62.70	20	26.70	4	5.30
16	75	3	4.00	48	64.00	16	21.30	8	10.70
Total	450	19	4.22	311	69.11	85	18.88	35	7.77

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Correlates of anemia and nutritional status

Micro-environmental, socio-economic, and demographic variables, along with dietary habits, were assessed for their association with the anemic and nutritional status of the sample girls using the chi-square test. Menarcheal status showed a significant relationship with the girls' nutritional status (with wasting: χ^2 = 28.588, p-value = 0.000**, expected count = 19.60; with stunting: χ^2 = 11.061, p-value = 0.011**, expected count = 10.45). The number of family members also demonstrated a significant association with the prevalence of wasting among the sample girls (χ^2 = 9.932, p-value = 0.019*, expected count = 5.70). A statistically significant association between household size (number of rooms) and the girls' anemic status was observed from the chi-square test values (χ^2 = 12.671, p-value = 0.013*, expected count = 0.62) (The detailed table has not been included intentionally).

Discussion

India continues to grapple with a dire nutritional situation. In the 2021 Global Hunger Index, India score dropped to 27.5, ranking 101st out of 116 countries, a decline from 94th place in 2020 (Index, 2021). Additionally, a survey on Global Food Policy conducted by the International Food Policy Research Institute in 2022 painted a grim picture, predicting that approximately 73.9 million Indians will experience hunger by 2030 (Swinnen et al., 2022). The overall nutritional landscape in India remains dismal, compounded by significant gender disparities in health care access and discrimination against women from birth onwards (Mehrotra, 2006; Sivakumar, 2008; Basu, 1993).

The National Family Health Survey (2019-21) reported that 15.9% of children under the age of 5 years suffer from wasting, 27.5% from stunting, and 21.5% from underweight. Since there is a lack of nationally representative data for the adolescent age group, it is crucial to compare the results of the present study with the findings of regional studies to develop a comprehensive understanding and to find regional variations. In the present study, we assessed the nutritional status of scheduled caste girls aged 11-16 years according to WHO standards, which showed 67.33% girls to be stunted and 64.90% girls to be wasted. The results of this study were compared with the prevalence of wasting and stunting among girls in various Indian states from several other studies. It was found that the sampled girls had a higher prevalence of stunting and wasting compared to girls in other population groups (Bose et al., 2007; Goyle, 2009; Vasisht et al., 2009; Mondal & Sen, 2010; Dambhare et al., 2010; Shivaramakrishna et al., 2011; Goyal et al., 2012; Srivastava et al., 2012; Fazili , 2012; Bhadniya et al., 2013; Gaiki & Wagh, 2014; Thakur & Gautam, 2016; Chauhan et al., 2022), with rates comparable only to those found in girls from Andhra Pradesh (Susmitha et al., 2015). These differences in prevalence rates of various statues of malnutrition may be attributed to different genetic and environmental correlates along with the socio-economic, different dietary habits levels and cut-off points used to define under nutrition.

Despite of the fact that there is an increase in economic opportunities and access to healthcare facilities in India, the incidence and prevalence of anemia is alarming. NFHS estimates from 2005–2006 to 2019–2021 suggest a slight increase in anemia prevalence among Indian adolescents aged 15–19 years (girls: 55.8% to 59.1%, boys: 30.2% to 31.1%) (International Institute for Population Sciences, 2022). Numerous region-specific studies are conducted annually to assess anaemia prevalence in children and adolescents. While exact figures vary among studies, anemia remains a critical public health issue in India, particularly among women and children. The present study focuses on the prevalence of anemia among adolescent girls (11–16 years) of Yamunanagar, Haryana. On comparison with other results of other regional studies, it was found that the prevalence of anemia among the girls in this study was 92.2%, which is lower than reported rates among girls in Jaipur (96.30%) (Goyle & Prakash, 2009) and Fatehgarh Sahib, Punjab (98.00%) (Kaur & Kaur, 2011), but higher than in other population groups (Sidhu et al., 2005; Basu et al., 2005 ; Goel & Gupta, 2007 ; Gupta & Kochar, 2009 ; Gupta et al., 2011 ; Gupta et al., 2012 ; Verma et al., 2013 ; Kaur & Kaur, 2015 ; Devi et al., 2015 ; Singh et al., 2015 ; Chandrakumari et al., 2019 ; Subramanian et al., 2022). These results indicate that anemia is a severe public health concern (prevalence ≥ 40%) in the studied population, according to the WHO current recommendations (2011a).

The present study showed a significant association between family size (number of family members) and prevalence of wasting among the sample girls. Many studies have reported that family size is a major determinant of poor nutritional status among adolescent girls (Kitai et al., 1996; Haidar et al., 2005; Odunayo & Oyewole, 2006; Mukherjee & Bhalwar, 2008; Balci et al., 2012). Mierzejewska (1995) stated that the smaller the family size, the better is the nutritional status. Eiben & Taylor (2004) reported a downward trend in body weight of children from Hungary (aged 3-18 years) with increasing family size. Abdelaziz et al. (2015) concluded in their study on Egyptian children and adolescents that larger family size leads to overcrowding and inadequate spacing thus, denoting to be a significant risk factor for severe malnutrition among children. Similar findings were reported by Bhattacharyya & Barua (2013) and Wolde et al. (2015). The results of the present study are in consensus with these studies.

Children in lower socio-economic groups, especially in developing countries, often suffer from malnutrition and associated health issues. The majority of the girls in the present study belonged to the lower socio-economic group. Nutritional status is one of the most important determinants that accounts for variability in menarcheal age (Riley et al., 1993). Blum et al. (1997) reported that to achieve menarche a minimum body fat mass is required, and an increased body fat mass is associated with earlier puberty and menarche. A delay in menarche is seen in the girls who are undernourished as compared to their better-nourished counterparts (WHO, 2003; Gluckman & Hanson, 2006). In the present study, the menarcheal status of the girls showed a significant relationship with the girls' nutritional status.

Anemia is typically caused by factors such as nutritional deficiencies (especially iron), chronic diseases, and genetic or environmental factors. However, the size of a house could indirectly affect anemia status through its association with socioeconomic status, which in turn can affect access to nutritious food, healthcare, and overall living conditions. In the present study, girls who lived in bigger houses showed better anemic status than girls who resided in smaller households. A statistically significant association was seen between the prevalence of anemia in the girls and the size of the residence.

It is worth noting that this study is the first of its kind to assess the nutritional status and prevalence of anemia, along with its associated factors (socio-demographic, micro-environmental, and lifestyle factors), among adolescent scheduled caste girls residing in Yamunanagar, Haryana. However, this study employed Sahli's acid hematin method using a hemoglobinometer to assess the anemic status of the scheduled caste girls, which is a convenient method for field conditions and offers a cost-effective and rapid means of identifying individuals at risk. However, it tends to underestimate the hemoglobin concentration, since not all forms of hemoglobin are converted to acid hematin. Additionally, subjective bias may be present due to visual comparison. Thus, this can be said to be the limitation of the study.

Conclusion

The present study sheds light on the poor nutritional status of the sampled adolescent girls, alongside an alarming prevalence of anemia among them. This nutritional inadequacy is largely attributed to poverty, as the majority of the girls belong to lower socioeconomic groups. Furthermore, family size and household size showed an association with their poor nutritional

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and anemic status. Therefore, crowding within the family may also contribute to the higher prevalence of malnutrition and anemia among them.

These findings underscore the urgent need for regular screening of adolescent girls and timely interventions to improve their nutritional status. Health policymakers must develop tailored intervention strategies addressing the specific causes and prevalence of anemia and malnutrition within different settings and population groups. Furthermore, policymakers should allocate sufficient resources and funding for the control and prevention of malnutrition in adolescent girls to safeguard their future health.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical Considerations

Ethical clearance for the collection of data on human subjects was obtained from the Ethical Review Committee of Panjab University, Chandigarh vide letter no. PU/IEC/97-1/13/11 dt 13/11/13. A prior permission was obtained from the DEO and Principals of schools along with the written consent of parents/legal guardians after explaining the objective and methodology of the study.

Author's contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by the P. A. G. Both P. A. G and I. T, contributed to manuscript writing. All authors read and approved the final manuscript.

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