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A comparative study of nutritional and health status of school-going adolescents from rural-urban gradient of North Bengaluru

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Abstract
Adolescents is a transition period and requires increased intake of essential nutrients. However, there is increasing prevalence of malnutrition and micronutrient deficiencies in adolescents. In the present study it was observed that the mean nutrient intake calculated based on the food intake of respondents was below the recommended dietary allowances across all the three areas. The micronutrient adequacy for iron, zinc, thiamine, riboflavin, niacin, and folate) ranged from 50-65%, while that of calcium and vitamin C were >80%, this possibly was due to staple food like ragi and increased citrus intake during the pandemic, as per anganwadi guidance. Macronutrients like energy and protein had adequacy above >80%, >75%, respectively; while the adequacy for total dietary fiber was >70%. Urban area exhibited significantly higher consumption of key micronutrients (zinc, niacin, vitamin A) than rural area. Haemoglobin values showed a significant association with area (p<0.05), with the highest proportion of respondents having normal levels in urban (35%) compared to rural (32%) and peri-urban (16%) areas; mild anemia was more prevalent in peri-urban (53%) and rural (53%) areas, followed by urban (51%) area. The chi-square analysis showed no significant area-based disparities in nutritional deficiencies and morbidity status. Dental caries was slightly higher in urban areas (15%), followed by peri-urban (4%) and rural (3%) regions, potentially due to elevated carbohydrate consumption. Prevalence of dermatitis (10%), pale eyes (10%) spoon-shaped nails (8%), mottled teeth (6%), and gastrointestinal issues (2%) highlight micronutrient deficiencies for vitamins and minerals. Addressing these health problems necessitates nutrition education interventions for rural communities to enhance their micronutrient-rich food intake. Overall, nutrition education is essential to boost fruit and vegetable consumption, curbing adolescent micronutrient deficiencies.

Keywords: Common ailments, health status, haemoglobin, nutrient adequacy

Introduction
Adolescence period from 10–19 years is characterized by transition (on physical, social and psychological levels) as defined by the World Health Organization (WHO). During this transitional period, there is need for increased intake of essential nutrients to support the rapid growth and development (Singh *et al*., 2019) [20]. Micronutrients, i.e., vitamins and minerals, are crucial role in maintaining various body functions, immune response, and overall vitality. Thus, ensuring an adequate intake of these nutrients is essential for promoting optimal growth, cognitive function, and overall health in adolescents (Savarino *et al*., 2021) [16]. Disappointingly, adolescents across the world suffer from micronutrient deficiencies and insufficient dietary intakes, that has profound and lasting impacts on their health and well-being (Calcaterra *et al*., 2023) [2]. Dietary patterns and preferences are greatly established at adolescent stage; and various factors are responsible for their formation (World Health Organization, 2005) [22]. Skipping meals, snacking in between meals, consumption of highly processed foods, empty calorie foods are some unhealthy eating habits have caused shifts in their dietary pattern having adverse impacts on their health. Socioeconomic status, education, peer pressure, surrounding environment and family status are some of the factors influencing the food choices and nutritional status of adolescents (Madjdian *et al*., 2022) [11]. Amongst all these, urbanization is one of the major factors leading to nutrition transition which imposes major risk of life-style disorders. This nutrition transition has led to poor eating habits, insufficient intake of essential nutrients, and an increased reliance on processed foods causing alarming increases in non-communicable disorders like obesity, malnutrition, and micronutrient deficiencies (Palla *et al*., 2020; Mesas *et al*., 2022) [14, 12]. These issues not only affect adolescents' physical health but can also influences cognitive development and

emotional well-being. Efforts to address these challenges can pave the way for a healthier and more productive generation of adolescents. Detailed investigations are thereby important to document the health and nutrient intake status of the adolescents to develop customised nutrition focused interventions for tackling with the increasing burden and challenge of malnutrition coupled with lifestyle disorders in adolescents. Thus, the present research was undertaken to document the nutrition and health profile of adolescents from rural, peri-urban and urban areas from North Bengaluru.

Materials and Methods

Study design and sample: Baseline data was collected using pre-tested interview schedule from 300 adolescents, 100 from each area i.e., rural, peri-urban and urban areas (50 girls and 50 boys each). Nutrient intake of the subjects was calculated based on the quantity of foods consumed. While nutrient adequacy was calculated comparing the actual intake with the recommended dietary allowances (RDA) (Longvah *et al*., 2017; ICMR-NIN, 2020) [10, 6].

Assessment of health status: Clinical symptoms were assessed to know about nutritional deficiency disorders and morbidity data using modified ICMR schedule (Srilakshmi 2017) [21]. The haemoglobin (Hb) values (g/dl) values were recorded as secondary data from medical records and compared with standards based on WHO classification as reported by Shaka, and Wondimagegne (2018) [18], to analyze the number of respondents falling in normal (girls: ≥12; boys: ≥ 13), mild (girls: 10 – 11.9; boys: 10 – 12.9), moderate (girls and boys: 7-9.9) or severe anemia (girls and boys: <7) category.

Nutrition education: Nutrition education was imparted regarding the importance of balanced diet and lifestyle modifications for adolescents. This was provided through classroom lecture, interactions and discussions, nutritional educational material like poster, booklets, charts, folders, presentations, and demonstrations. Figure 1 shows the selected nutritional material used for imparting nutrition education. The impact of nutrition education training was assessed through a feedback form consisting of 10 dichotomous questions (yes or no type) with one mark each (Maximum score: 10, Minimum score: 0).

Statistical analysis: Suitable statistical analysis was used for interpretation of data. The data was represented as frequency, percentage and mean ± sd (standard deviation) wherever suited. Suitable statistical tests i.e., chi-square test was applied.

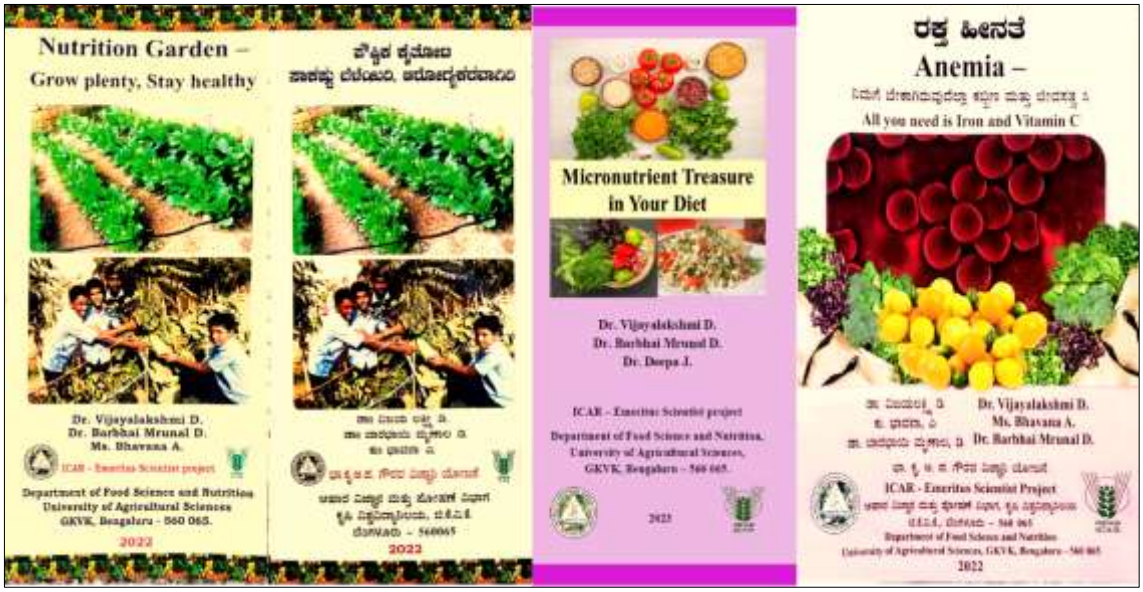


Fig 1: Selected Nutrition education material

Research ethics: The study was conducted after the approval of Institutional Ethics Committee (IEC), University of Agricultural Sciences, GKVK, Bengaluru (No. DR/STA/Ethical Committee/2020-21) dated 05-04-2021) as human participants were involved. A written consent was obtained from participants as well as their parents/guardians, teachers in English/ local language.

Results and Discussions

Changes in food consumption pattern in last few decades have led to nutrition transition. The results of the present study indicated that age of subjects from all the three areas was not significantly different. In total, 35 percent subjects were 14-year-old, followed by 33 and 32 percent belonging to 13 years and 15 years respectively. Education of the subjects was 8th, 9th and 10th with no area-wise significant difference.

Nutrient intake and percent adequacy of respondents: The mean nutrient intake was calculated based on the average food intake recorded for the respondents. The nutrient intake and percent adequacy for both the groups (girls and boys) compared across area are presented in Table 1, 2 and Fig 1. Results showed that the mean nutrient intake was lower than the recommended dietary allowances (RDA) suggested by Indian Council of Medical Research (ICMR 2020) [6] for adolescents from all the areas. Similarly, Kumari and Singh (2003) [9] indicated that intake nutrients were lower than their respective RDA amongst adolescents (13-18 years). The intake of food and nutrients by the females was comparatively lower than males.

In terms of percent nutrient adequacy, majority of micronutrients viz. iron, zinc, thiamine, riboflavin, niacin, folate had adequacy only up to 50 – 65 percent; while energy,

protein, calcium, vitamin C had adequacy above >80%, >75%, >80%, >80% respectively. The adequacy of total dietary fiber was > 70%. The reason for higher intake of calcium was daily consumption of ragi as their staple food. The subjects also confirmed daily consumption of lemon during covid pandemic, as the anganwadi teachers provided nutrition awareness and insisted daily consumption of cirtus foods to boost immunity. Previous study by Shafiee *et al*., (2015) [17] has also indicated that the intake of nutrients was less in adolescents compared to RDA.

Comparison amongst the adolescent girls and boys area-wise, it was observed that consumption of majority micronutrient (zinc, niacin, vitamin A) was significantly higher in the urban area than rural area (Table 1, 2, Fig 2). This was inline with the study conducted by Arlappa *et al*. (2010) [1] indicating that micronutrients such as vitamin A, iron, riboflavin and folic acid were extremely deficient in diets of rural population. Thus it is necessary to provide rural communities with proper health and nutrition education to increase their intake of micronutrient rich foods. The overall results designate that there is need for nutritional education for improving the intake of fruits and vegetables to meet the nutritional needs of the adolescents for reducing the burden of micronutrient deficiencies.

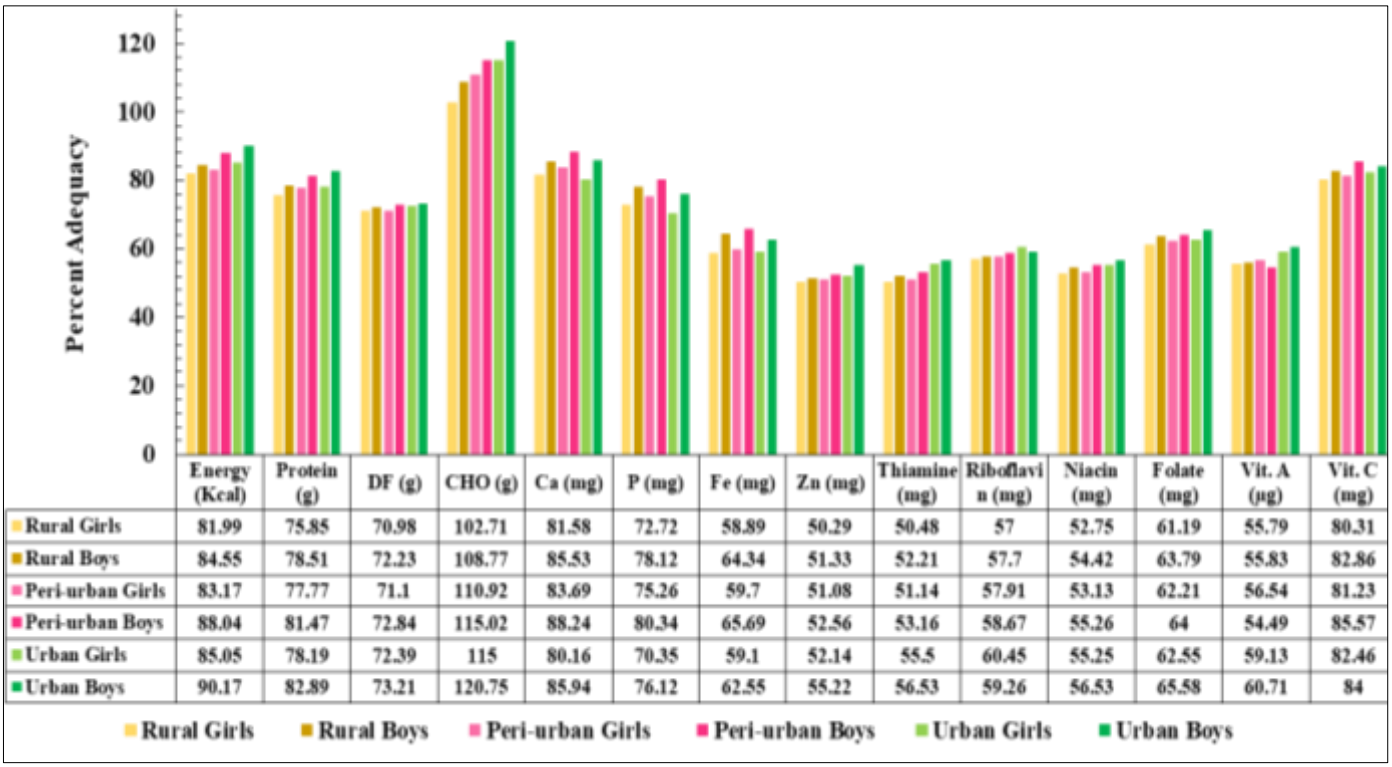
Table 1: Mean nutrient intake of the adolescent girls

Nutrients	Rural (N= 50)	Peri-urban (N=50)	Urban (N=50)	Total (N=150)	p value
Energy (Kcal) #	1967.73±283.00	1996.17±224.16	2041.27±242.79	2001.73±251.34	0.339
Protein (g)	32.61±8.66	33.44±4.79	33.62±5.07	33.22±6.39	0.706
Fat (g)	23.47±11.00^{a}	25.58±6.81^{ab}	28.22±5.37^{b}	25.76±8.27	0.015*
Dietary fiber (g)	25.55±5.30	25.60±3.84	26.06±3.27	25.74±4.20	0.802
CHO (g)	133.52±37.51^{a}	144.20±37.64^{ab}	149.50±30.44^{b}	142.41±35.75	0.074*
Ca (mg)	815.82±299.85	836.88±166.74	801.63±150.78	818.11±215.40	0.715
P (mg)	727.17±219.32	752.58±141.16	703.52±56.84	727.76±154.40	0.285
Fe (mg)	17.67±3.92	17.91±3.42	17.73±2.43	17.77±3.29	0.930
Zinc (mg)	6.44±0.33^{a}	6.54±0.36^{ab}	6.67±0.37^{b}	6.55±0.36	0.004*
Thiamine (mg)	0.81±0.26	0.82±0.25	0.89±0.20	0.84±0.24	0.193
Riboflavin (mg)	1.25±0.28	1.27±0.28	1.33±0.25	1.29±0.27	0.355
Niacin (mg)	8.44±0.61^{a}	8.50±0.79^{a}	8.84±0.74^{b}	8.59±0.73	0.012*
Folate (mg)	149.92±46.71	152.42±24.26	153.25±24.49	151.87±33.32	0.875
Vit. A (µg)	496.50±28.65^{a}	503.20±45.15^{a}	526.30±48.56^{b}	508.67±43.36	0.001
Vit. C (mg)	52.20±3.80	52.80±3.80	53.60±5.44	52.87±4.43	0.285

Table 2: Mean nutrient intake of the adolescent boys

Nutrients	Rural (N= 50)	Peri-urban (N=50)	Urban (N=50)	Total (N=150)	p value
Energy (Kcal)#	2418.18±196.67^{a}	2518.18±259.86^{b}	2579.00±268.66^{b}	2505.06±251.17	0.005*
Protein (g)	35.33±8.09	36.66±6.05	37.30±5.30	36.43±6.59	0.315
Fat (g)	35.46±2.90^{a}	37.58±6.45^{a}	40.32±8.31^{b}	37.79±6.57	0.001*
Dietary fiber (g)	31.06±3.96	31.32±3.74	31.48±6.86	31.06±5.03	0.916
CHO (g)	217.55±27.66^{a}	230.04±65.09^{ab}	241.50±46.12^{b}	217.55±49.50	0.052
Ca (mg)	855.34±214.99	882.45±109.08	859.40±140.95	855.34±160.59	0.664
P (mg)	781.25±225.65	803.41±126.30	761.20±90.50	781.25±158.06	0.412
Fe (mg)	14.15±2.12	14.45±1.52	13.76±1.97	14.15±1.90	0.188
Zinc (mg)	7.34±0.29^{a}	7.52±0.42^{a}	7.90±0.76^{b}	7.34±0.57	0.000*
Thiamine (mg)	0.99±0.14^{a}	1.01±0.19^{a}	1.07±0.15^{b}	0.99±0.16	0.030*
Riboflavin (mg)	1.56±0.39	1.58±0.40	1.60±0.29	1.56±.36	0.843
Niacin (mg)	10.34±1.30	10.50±1.31	10.74±1.61	10.34±1.42	0.367
Folate (mg)	181.80±39.47	182.40±37.28	186.90±23.99	181.80±34.12	0.719
Vit. A (µg)	519.20±17.83^{a}	506.80±45.24^{a}	564.60±71.95^{b}	519.20±55.69	0.000*
Vit. C (mg)	58.00±10.69	59.90±11.72	58.80±6.97	58.00±9.96	0.635

Note: The data of mean nutrient intake is based on calculated values derived from the foods consumed by the respondents. Different alphabets in rows indicate significant difference. #Energy is represented as EER (Estimated Energy Requirement) as there is no RDA for energy.



Note: *Energy is represented as EER (Estimated Energy Requirement) as there is no RDA for energy.

Fig 2: Area-wise nutrient adequacy of adolescent girls and boys

Haemoglobin status: Area had significant association with haemoglobin values. The respondents with normal haemoglobin levels were highest in urban (35%) area than rural (32%) and peri-urban (16%) area. However mild anemic respondents were more in peri-urban area followed by rural (53%) and urban (51%) areas (Table 2). Shedole *et al*., (2017) [19] compared prevalence of anemia between adolescent girls from rural and urban area and reported that prevalence of anemia was higher in rural adolescent girls than urban. Heamoglobin classification indicated that >70 percent adolescents were anemic, with girls (75%) and boys (71%) having either mild, moderate or severe anemia. Only 26 percent girls and 29 percent boys were normal, with heamoglobin above 12 g/dl and 13 g/dl respectively (Table 2). In case of mild anemia prevalance was more in boys (59%) than girls (53%). In a study conducted by Zeleke *et al*., (2020) [23], it was indicated that amongst school children from 10 – 19 years from Dilla town Ethiopia, higher anemia prevalence was detected in male than female children. Similarly, Shaka, and Wondimagegne (2018) [18], also suggested that anemia is moderate public health concern and both adolescent boys and girls are at risk for the development of anemia. Thus, there is need to conduct in-depth research for analyzing the causes and factors associated with male anemia. Additionally, the anemia policies or programmes only emphasizing on female population can be modified with equal attention to anemia as problem in male counterparts. Similar suggestions have been given by Kumar *et al*., (2021) [8] and Chauhan *et al*., (2022) [5] for reformulating anemia progammes considering both the male population along with female population. On other hand, Chandrakumari *et al*., (2019) [4] indicated that prevalence of anemia among adolescent girls was found to be 48.63% and there is a significant relationship between anaemia, socioeconomic status, dietary modification and nutritional supplementation.

Table 2: Distribution of respondents according to haemoglobin classifications

Haemoglobin (mg/dl)	Gender		Area			Grand Total (N=300)
	Girls (n=150)	Boys (n=150)	Rural (n=100)	Peri-urban (n=100)	Urban (n=100)	
	%	%	%	%	%	%
Normal	26	29	32	16	35	27
Mild	53	59	53	64	51	56
Moderate	19	11	13	19	12	15
Severe	3	1	2	1	2	2
χ^2	5.969		χ^2	21.901		
p value	0.113		p value	0.009*		

Note: Data is represented as percentage and analyzed using Chi-Square Test. *Indicates significant difference

Health status of the respondents: Health status of the adolescents was recorded using modified ICMR schedule to record clinical symptoms in relation to nutritional deficiency symptoms and morbidity status. Chi-square results of the nutritional deficiencies status of the respondents indicated no area-wise significant difference amongst the respondents. A total of 15 percent respondents had dental caries, 11 percent reported giddiness and 10 percent each had pale eyes and

dermatitis. Dental caries (15%) was more in urban respondents (8%) followed by peri-urban (4%) and rural (3%), which could be due to the higher intake of carbohydrates or sugary foods. These findings were concurrent with Kashyap and Kaur (2015) [7]; Nataraj (2017) [13], and Patil (2019) [15]. Apart from these deficiencies 8 percent had spoon shaped nails, 6 percent mottled teeth and 2 percent gastrointestinal problems. Only respondents from rural area reported gastrointestinal problems. All these deficiency symptoms indicated micronutrient deficiency especially for vitamins like B-complex and minerals like iron and zinc. Chakraborty *et al*., (2018) [3] found that prevalence of B-complex vitamin deficiency was higher among rural school-going adolescents.

Table 3: Nutrient deficiency symptoms of the respondents

*Nutrient deficiencies symptoms	Respondents			Total (N=300)	χ^2 value	p value
	Rural (%)	Peri-urban (%)	Urban (%)			
Spoon shaped nails	1	5	2	8	3.339	0.188
Pale eyes	6	1	3	10	3.931	0.140
Giddiness	6	1	4	11	3.586	0.166
Mottled tooth	2	2	2	6	2.007	0.735
Dental caries	3	4	8	15	2.947	0.229
Gastrointestinal disorders	2	0	0	2	4.027	0.134
Dermatitis	4	2	4	10	0.828	0.661

**Note: ***These were multiple response questions.

Common ailments of the respondents: Morbidity status for the illness experienced during past six months indicated (Table 4), that majority respondents suffered from general weakness (33%), loss of appetite (31%), pain in lower back (26%), eye strain (25%), head ache (21%), cold (19%), stomach pain (19%), body ache (18%), fever (17%), and cough (17%). No significant difference was noted in the area and the common ailments. Comparison between the areas revealed that most of the common ailments were higher in rural respondents than peri-urban and urban area. Patil (2019) [15] also reported similar morbidity data amongst adolescents for prevalence of gastritis, back ache, body ache, cough, and cold. Similarly, Nataraj (2017) [13], reported higher prevalence of common illness like cold, cough, fever, diarrhoea and stomach ache in both boys and girls of government schools. It was remarked by the author that consumption of low-quality food could have been a reason for low immunity thereby reducing capacity of body to fight infections.

Table 4: Morbidity status of the respondents

*Morbidity status	Respondents			Total (N=300)	χ^2 value	p value
	Rural	Peri-urban	Urban			
Cold	10	5	4	19	3.484	0.175
Cough	8	5	4	17	1.621	0.445
Fever	8	5	4	17	1.621	0.445
Loss of appetite	12	11	8	31	0.935	0.626
Diarrhoea	5	3	2	10	1.448	0.485
Stomach ache / pain abdomen	8	6	5	19	0.787	0.675
Head ache	5	11	5	21	3.687	0.158
Body ache	9	5	4	18	2.482	0.289
Throat pain	4	3	4	11	0.189	0.910
Tooth pain	3	4	4	11	0.189	0.910
Eye strain	9	7	9	25	0.349	0.840
Pain in hands and legs	4	1	1	6	5.048	0.282
Fatigue	2	2	1	5	0.407	0.816
General weakness	13	11	9	33	0.817	0.665
Acidity	2	2	3	7	0.293	0.864
Pain in lower back	11	10	5	26	2.611	0.271
Vomiting	1	2	0	3	2.020	0.364

Note: *Multiple responses

Nutrition education: Feedback for one day-nutrition education workshop imparted in the present study was scored (out of 10) by the respondents (n=300). It was observed that out of 300 subjects 30 percent scored the intervention as 10 out of 10, followed by 25 percent giving 9 score, 21 percent with 8 score, 16 percent with 7 and remaining 8 percent scored 6. This indicated that nutrition education workshop was successful and such need based programmes can be implemented in schools.

Conclusion

It was also indicated that the intake of major micronutrients viz. iron, zinc, thiamine, riboflavin, niacin, folate met 50 percent of RDA. Higher prevalence of mild anemia was detected in boys than girls, thus attention is required on framing and updating the health-related policies equally considering both adolescents boys and girls. Nutrition education interventions were able to motivate the adolescents towards healthy eating and including micro-nutrients in their diet. Thus, the present descriptive study could provide basis to

document, associate and plan nutritional interventions, strategies and policies.

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Conflict of interest
All the authors declare that there are no conflicts of interest.

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