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DIFFERENCES IN HEMATOLOGICAL PARAMETERS AND NUTRITIONAL INTAKE BASED ON ENVIRONMENTAL CONDITION IN THE ISLAM BOARDING SCHOOLS

Mohammad Zen Rahfiludin[1*], Tri Joko[2], Alfi Fairuz Asna[3], Septo Pawelas Arso[4], Lilik Hidayanti[5]

[1,2,3,4]Faculty of Public Health, Diponegoro University, Semarang 50275, Indonesia
[5]Faculty of Health Science, Siliwangi University, Tasikmalaya 46115, Indonesia

ABSTRACT

Anemia and iron deficiency anemia (IDA) are indirectly caused by environmental factors. However, there are currently no studies on the differences in hematological parameters of anemia and nutritional intake in adequate and inadequate environmental conditions. This study aims to determine the differences in hematological parameters and nutritional intake of female students based on the environmental conditions of the Islamic boarding schools. It was a descriptive study with a cross-sectional design. A total of 167 girls from seven Islamic boarding schools in Tasikmalaya, West Java were recruited. Anemia was assessed by determining hemoglobin (Hb) levels, hematocrit (Ht) levels, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH,) and mean corpuscular hemoglobin (MCHC). Environmental conditions of the boarding schools observed were the kitchen, bedrooms, toilet/bathrooms, and the outside environment (trash bins and handwashing stations). The study found that there is no difference in the hematological values (Hb, Ht, MCV, MCH, MCHC, and RDWCV) of students with adequate and inadequate environmental conditions. Students who lived in inadequate environment had higher intake of iron ($p<0.005$), protein ($p<0.005$), and vitamin C ($p<0.005$) than those who lived in adequate environment. However, the nutritional intake of adolescent girls in Islamic boarding schools was considerably lower than Indonesian Recommended Dietary Allowance (RDA). Thus, no significant difference in hematological levels, which are indicators of anemia and IDA, could be found. Hence, to protect against anemia and IDA, adolescent girls should increase the quality and quantity of their nutritional intake, particularly iron, protein, and vitamin C.

Key words: *anemia, adolescent girls, boarding schools, environmental condition, nutritional intake.*

ABSTRAK

Anemia dan anemia defisiensi besi (IDA) secara tidak langsung dapat disebabkan oleh faktor lingkungan. Namun, belum ada penelitian yang menganalisis perbedaan parameter hematologi, sebagai indikator anemia, dan asupan gizi pada kondisi lingkungan yang baik dan kurang baik. Tujuan penelitian ini adalah mengetahui perbedaan parameter hematologi dan asupan gizi santriwati berdasarkan kondisi lingkungan pondok pesantren. Penelitian ini merupakan penelitian deskriptif dengan desain study cross sectional pada 167 santriwati dari tujuh pondok pesantren di Tasikmalaya, Jawa Barat. Status anemia ditentukan melalui analisis kadar hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), dan mean corpuscular hemoglobin (MCHC). Faktor lingkungan diketahui melalui observasi kondisi lingkungan pesantren yang meliputi dapur, kamar tidur, toilet/kamar mandi, dan lingkungan luar (tempat sampah dan tempat cuci tangan). Penelitian ini menemukan bahwa tidak ada perbedaan kadar hematologi (Hb, Ht, MCV, MCH, MCHC, dan RDWCV) diantara siswa yang tinggal di lingkungan dengan kondisi yang baik dan kurang baik. Santriwati yang tinggal di lingkungan kurang baik memiliki asupan besi ($p<0.005$), protein ($p<0.005$), dan vitamin C ($p<0.005$) lebih tinggi daripada santriwati yang tinggal di lingkungan yang baik. Meskipun demikian, asupan gizi pada remaja putri di pondok pesantren masih jauh dibawah rekomendasi Angka Kecukupan Gizi (AKG) sehingga menyebabkan tidak adanya perbedaan signifikan pada kadar hematologi yang menjadi indikator anemia dan IDA. Oleh karena itu, untuk melindungi dari anemia dan IDA, remaja putri disarankan untuk meningkatkan asupan gizi, terutama besi, protein, dan vitamin C.

Kata kunci: anemia, remaja putri, pesantren, kondisi lingkungan, asupan zat gizi.

Correspondence Address: Mohammad Zen Rahfiludin, Faculty of Public Health, Diponegoro University, Semarang 50275, Indonesia,
E-mail: rahfiludinfkmundip@gmail.com,

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Introduction

Anemia is a condition in which the hemoglobin level in the blood is lower than normal and is not sufficient to meet physiological needs. Normal hemoglobin levels in adolescent girls are >12 g/dL. The World Health Organization (WHO) estimates that more than two billion people worldwide are anemic. Among women of reproductive age (15-49 years old) in 2011, the prevalence of anemia worldwide was 81.5%.[1] The prevalence of anemia among adolescent girls in developed and developing countries was estimated to be 6% and 27%, respectively.[2] Based on the results of the 2018 Basic Health Research study, the proportion of anemia in Indonesia among children aged 5-14 years old was 26.4% and for the 15-24 age group was 18.4%.[3] In 2018, the rate of anemia increased to 32% for the 15-24 year age group.[4]

During adolescence, demand for macronutrients and micronutrients increases to accommodate the growth that occurs during puberty. Adolescent girls are, as a group, prone to developing anemia because of a high need for iron for growth, in addition to a need to compensate for iron loss during menstruation.[5] The amount of iron lost during menstruation depends on the amount of blood lost during each menstrual period. Low iron absorption can result in iron deficiency and a subsequent decrease in iron stores.[6] The current nutritional status of young women can affect the health of both present and future generations. Long-term effects of anemia include stunting, decreased learning achievement, reduced immune function, and irregular menstruation.[7] Anemia in adolescent girls contributes to an increased rate of miscarriage and maternal mortality, as well as an increased incidence of low birth weight and perinatal mortality.[8] Prevention and treatment efforts are needed to address this major public health problem and to improve the health and well-being of adolescent girls in Indonesia.[9]

Overcoming nutritional deficiencies can be achieved with multi-sector cooperation through nutrition improvement interventions, both special and sensitive nutrition interventions. Special nutrition interventions by the health sector represent a direct effort to prevent and reduce nutritional problems, for instance, promoting the consumption of iron-rich foods (e.g., meat, fish, and poultry, legumes, and green leafy vegetables) and foods that enhance iron absorption to adolescent girls.[10] Sensitive nutrition interventions, such as environmental health interventions, are indirect efforts of the non-health sector to prevent and reduce nutritional problems.[11]

The environment is a factor associated with the incidence of anemia. Poor environmental conditions is a risk factor of infectious diseases, such as hookworm infestation and malaria, resulting in the lack of nutrients such as iron and vitamins.[12] The presence of malaria parasites in the body increases the risk of anemia by five times in adolescent girls.[13] In India, the history of

worm infestation was correlated with severe anemia among adolescents aged 10-18 years.[14] Thus, unclean environmental conditions can be an indirect cause of anemia. Mengistu et al. found that anemia is a public health problem among adolescent girls in rural schools in Bahir Dar in northwestern Ethiopia in which predictors of anemia include infectious diseases, length of menstruation, BMI according to age, monthly household income, and number of family members.[15] Sunuwar et al. considered seven countries in South and Southeast Asia and showed that environmental factors could contribute to the incidence of anemia.[16]

In Indonesia, numerous studies have examined anemia among female students at Islamic boarding schools. These studies, however, have either examined the relationship between anemia and nutritional intake[17–19] or examined the association between anemia and environmental factor[20,21] in two separate analyses. We are not aware of any study examining nutritional intake and hematological indicators of anemia based on different environmental conditions in the Islamic boarding schools. The study aimed to determine the differences in hematological parameters and nutritional intake of female students based on the environmental conditions of the Islamic boarding schools.

Method

This descriptive study had a cross-sectional design and was conducted in August 2020. A total of 167 students from seven Islamic boarding schools were enrolled. The levels of hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were analyzed in 3 mL blood samples collected from study participants. Iron deficiency anemia (IDA) was determined based on levels of Hb, MCV, MCH, and MCHC. The normal hemoglobin level for women is 12 g/dL. A hematocrit for women ≤36% is considered to be abnormal. The threshold values for the red blood cell indices are: MCH <27 pg, and MCHC <32 g/dL, MCV <80 fL.[22]

Subjects reported daily meals received at the school cafeteria and food or snacks bought outside of school using a 24-hour dietary recall for three non-consecutive days. Food intake was recorded in local household measures (tablespoons, teaspoons, cups, etc.). After that, the data was converted into grams and analyzed using the Nutrisoft software to calculate nutritional intake.

The environmental conditions of the boarding schools observed were the kitchens, bedrooms, toilets, bathrooms, and the outside environment (e.g., trash cans and handwashing facilities). A score of 1 to 4 was given for each environmental indicator observed and the maximum total score was 20. Islamic boarding schools with a total score ≥10 were categorized as an adequate environment, while those with a total score <10 were categorized as an inadequate environment. Based on the total score, Islamic boarding schools UW and SBH (82 people) had adequate environment. In contrast, the other five Islamic boarding schools, which were AT, SYH, SLH, AI,

and AN (85 people), had inadequate environment. We categorized the scoring results to enable sound statistical analysis since it is impossible to analyze the correlation of anemia with the environmental factor with only seven Islamic boarding schools as sample.

The collected data were edited, coded, and entered for data cleaning. Data were analyzed statistically using SPSS software version 23. Descriptive data were reported as percentages or as means and SDs for normally and as medians for non-normally distributed variables. The Mann-Whitney test was used to analyze differences in hematological parameters (Hb, Ht, MCV, MCH, MCHC, and RDWCV) and nutritional intake based on the category of environmental condition (adequate and inadequate). The trained enumerator collected the data, and Prodia Laboratory examined the blood samples. We minimized bias in the environmental condition assessment by allocating only one person to observe. This study passed ethical review by the Ethics Commission for Health Research, Faculty of Public Health, Diponegoro University (No. 29/EA/KEPK-FKM/2020). Although a field study was conducted during the COVID-19 pandemic, researchers were allowed to enter areas of the Islamic boarding schools because they were in the green zone and we ensure to implement health protocols throughout the data collection.

Results

The students in this study were between 12- and 20-years-old. Hb level was used as an indicator of anemia. Ht levels, MCV, MCH, and MCHC were indicators of iron deficiency anemia (IDA). The AT and SLH boarding schools had the highest and lowest proportion of students with anemia at 57.1% and 19%, respectively (Table 1).

Table 1. Cross-Tabulation of The Incidence of Anemia at Each Boarding School

Islamic Boarding School	Status		Total
	Anemia	Normal	
UW	21 (42.0%)	29 (58.0%)	50 (100%)
AT	4 (57.1%)	3 (42.9%)	7 (100%)
SYH	6 (40.0%)	9 (60.0%)	15 (100%)
SBH	8 (25.0 %)	24 (75.0%)	32 (100%)
SLH	4 (19.0%)	17 (81.0%)	21 (100%)
AI	4 (23.5%)	13 (76.5%)	17 (100%)
AN	7 (28.0%)	18 (72%)	25 (100%)

Female students who experienced anemia in the AT boarding school were found to have IDA (42.9%), while the AI boarding school had the lowest proportion of students with IDA (11.8%). AT boarding school had the highest proportion of anemic non-iron deficient students (14.3%), and UW boarding schools was the second highest with a slightly lower percentage at 14%. (Table 2).

Table 2. Cross-Tabulation of The Incidence of Iron Deficiency Anemia at Each Boarding School

Islamic Boarding School	Status				Total
	Anemic, iron-deficient	Anemic, non-iron-deficient	Non-anemic, iron-deficient	Non-anemic, non-iron-deficient	
UW	14 (28.0%)	7 (14.0%)	2 (4.0%)	27 (54.0%)	50 (100%)
AT	3 (42.9%)	1 (14.3%)	0 (0%)	3 (42.9%)	7 (100%)
SYH	4 (26.7%)	2 (13.3%)	0 (0%)	9 (60.0%)	15 (100%)
SBH	5 (15.6 %)	3 (9.4%)	1 (3.1%)	23 (71.9%)	32 (100%)
SLH	4 (19.0%)	0 (0%)	1 (4.8%)	16 (76.2%)	21 (100%)
AI	2 (11.8%)	2 (11.8%)	1 (5.9%)	12 (70.6%)	17 (100%)
AN	5 (20.0%)	2 (8.0%)	1 (4.0%)	17 (68.0%)	25 (100%)

Table 3 shows the distribution of hematological characteristics (Hb, Ht, MCV, MCH, MCHC, and RDWCV) according to boarding schools. The SLH school had the highest mean ± SD of Hb, Ht, MCV, and MCH of 12.71 ± 1.32 g/dL, 38.65 ± 3.09%, 83.6 ± 4.94 fL, and 27.48 ± 2.39 pg, respectively. The AT school, in addition to having the highest incidence of anemia, also had the lowest mean ± SD for Hb, Ht, MCV, and MCH of 11.47 ± 1.79 g/dL, 35.73 ± 4.34%, 74.4 ± 12.08 fL, and 23.9 ± 4.73 pg, respectively. The highest and lowest mean ± SD MCHC was seen for AI (33.07 ± 1.30 g/dL) and AT (32 ± 1.39 g/dL) schools, respectively. The highest mean ± SD RDWCV was found at the AT Islamic boarding school (15.03 ± 3.21%) and the SLH Islamic boarding school had the lowest mean ± SD RDWCV (13.34 ± 1.59%).

Although almost half of the anemic students came from UW boarding schools (42%), the mean ± SD of hemoglobin level was not the lowest and was around a similar level as SYH boarding schools, which was in the bottom three of the lowest hemoglobin level in average. AT boarding school was the only school with Ht level below 36%. For the red blood cell indices indicator, only SLH boarding schools had normal MCH, which was more than 27 pg, while none of the schools had MCHC below 32 g/dL. Of seven boarding schools, there were three schools with MCV within the normal category (>80 fL), which were SBH, SLH, and AN boarding schools.

Table 3. Levels of Hb, Ht, MCV, MCHC, RDWCV in Female Students

Islamic Boarding School	Variable	N	Minimum	Maximum	Mean±SD
UW	Hb (g/dL)	50	8.5	14.2	11.89±1.52
	Ht (%)		28.0	42.3	36.92±3.69
	MCV (fL)		60.5	91.9	79.78±7.24
	MCH (pg)		18.9	30.4	25.71±3.05
	MCHC (g/dL)		28.6	36.1	32.15±1.38
	RDWCV (%)		11.8	19.3	13.93±1.64
AT	Hb (g/dL)	7	8.4	13.5	11.47±1.79
	Ht (%)		28.6	40.7	35.73±4.34
	MCV (fL)		59.0	86.6	74.40±12.08
	MCH (pg)		18.4	28.7	23.90±4.73
	MCHC (g/dL)		29.4	33.2	32.00±1.39
	RDWCV (%)		12.5	20.9	15.03±3.21
SYH	Hb (g/dL)	15	6.5	14.0	11.95±1.85
	Ht (%)		24.0	42.5	36.52±4.24
	MCV (fL)		56.5	92.3	77.89±10.45
	MCH (pg)		15.3	30.0	25.47±4.32
	MCHC (g/dL)		27.1	35.8	32.54±1.93
	RDWCV (%)		11.7	19.6	14.67±2.54
SBH	Hb (g/dL)	32	8.8	14.5	12.63±1.23
	Ht (%)		29.6	42.5	38.39±2.99
	MCV (fL)		60.2	91.8	81.09±7.05
	MCH (pg)		18.9	31.1	26.71±2.95
	MCHC (g/dL)		29.7	35.5	32.87±1.19
	RDWCV (%)		11.8	21.4	13.69±1.97
SLH	Hb (g/dL)	21	9.6	14.7	12.71±1.32
	Ht (%)		31.9	43.5	38.65±3.09
	MCV (fL)		73.0	90.2	83.60±4.94
	MCH (pg)		22.1	30.7	27.48±2.39
	MCHC (g/dL)		30.1	34.1	32.84±1.28
	RDWCV (%)		11.4	17.6	13.34±1.59
AI	Hb (g/dL)	17	9.8	14.3	12.67±1.27
	Ht (%)		30.6	42.5	38.26±3.14
	MCV (fL)		60.5	88.6	77.94±8.33
	MCH (pg)		19.4	29.3	25.81±3.12
	MCHC (g/dL)		30.8	35.9	33.07±1.30
	RDWCV (%)		11.8	19.7	14.24±2.07
AN	Hb (g/dL)	25	10.3	13.8	12.40±.77
	Ht (%)		33.1	42.0	38.32±2.08
	MCV (fL)		64.0	88.2	80.50±6.09
	MCH (pg)		19.6	30.0	26.09±2.54
	MCHC (g/dL)		30.6	34.0	32.37±.97
	RDWCV (%)		12.0	16.4	13.58±1.17

Abbreviations: IBS, Islamic Boarding School; Hb, hemoglobin; Ht, hematocrit; MCV, mean corpuscular volume; MCHC, mean corpuscular hemoglobin concentration; MCH, mean corpuscular hemoglobin; RDWCV, red blood cell distribution width.

Environmental Conditions of Islamic Boarding Schools

The environmental conditions observed at Islamic boarding schools included bathrooms/toilets, kitchens, bedrooms, and the outside environment. The bathroom/WC environment included the number of bathrooms, the ratio of bathrooms to students, and the condition of the toilets. Type of fuel used for cooking, availability of a place to wash food with running water, presence of a chimney, and presence of a trash can were factors evaluated for the kitchen environment. The bedroom environment included the type of bedding, type of flooring, ventilation, lighting, and the presence of hanging clothes. For the characteristics of external

environment, we evaluated the availability of trash cans and facilities for handwashing. The observations showed that not all kitchens had chimneys, but all schools had trash cans.

The UW Islamic boarding school had unclean kitchens and bedrooms, which had inadequate lighting. This school also had tile floors and hanging clothes. The outdoor environment was not clean, but there were handwashing facilities with clean running water and soap. The bathroom conditions were not adequate, as evidenced by a 1:50 ratio of bathrooms to students, and the toilets were not clean. At the AT boarding school, the kitchen was also unclean and they used firewood for cooking rice. The bedrooms were quite clean and had floor mattresses atop tile floors. The outside environment was not clean. The bathrooms were adequate (1:6.75), although the toilets were not clean (Table 4).

Table 4. Islamic Boarding School Environmental Conditions

	External Environment	Kitchen	Bedroom	Bathroom	Toilet
IBS UW	1	1	1	1	1
IBS AT	2	1	3	5	1
IBS SYH	3	2	3	5	4
IBS SBH	1	1	1	4	2
IBS SLH	2	3	3	3	3
IBS AI	3	4	4	5	3
IBS AN	3	1	2	4	3

Abbreviations: IBS, Islamic Boarding School.
Categories for the external environment, kitchens, bedrooms, toilet: 1 = dirty, 2 = less clean; 3 = clean enough; 4 = clean.
Category scores for toilets / bathrooms: weighted value 1 = ratio 41-50; value 2 = ratio 31-40; value 3 = ratio 21-30; value 4 = ratio 11-20; value 5 = ratio 1-10.

The results of the Mann-Whitney analysis showed that all hematological parameters (Hb, Ht, MCV, MCH, MCHC, and RDWCV) did not differ significantly among female students based on environmental conditions. However, dietary intake of iron (p = 0.001), protein (p = 0.006), and vitamin C (p = 0.004) was higher in students with inadequate environments compared to those who lived in an adequate environment (Table 5).

Table 5. Hematological Parameters and Nutritional Intake of Adolescent Girls at Islamic Boarding Schools Based on Environmental Condition Category

Variables	Adequate environment (n = 85)	Inadequate environment (n = 82)	*p*-value
Hematological parameters			
Hb (g/dL)	12.6 (6.5-14.7)	12.5 (8.5-14.5)	0.468
Ht (%)	37.9 (24.0-43.5)	38.1 (28.0-42.5)	0.767
MCV (fL)	82.4 (56.5-92.3)	82.0 (60.2-91.9)	0.926
MCH (pg)	27.3 (15.3-30.7)	26.8 (18.9-31.1)	0.629
MCHC (g/dL)	32.8 (27.1-35.9)	32.5 (28.6-36.1)	0.211
RDWCV (%)	13.3 (11.4-20.9)	13.3 (11.8-21.4)	0.879
Nutritional intake			
Iron (mg/day)	5.3 (0.6-14.7)	7.3 (3.1-12.7)	0.001
Protein (g/day)	25.6 (5.0-63.2)	31.6 (12.5-77.3)	0.006
Vitamin C (mg/day)	2.1 (0.0-21.2)	3.9 (0.0-117.5)	0.004

Discussion

This study discovered that the prevalence of anemia among female students in Islamic boarding schools ranged from mild to severe and none of them was in the normal range according to WHO standard, which is ≤ 4.9% in a population. Prevalence of anemia in Islamic boarding school SLH was the lowest and of mild public health significance, whereas Islamic boarding schools SBH, AI, and AN were of moderate category. We found severe anemia prevalence, in which the percentage was more or equal to 40%,[23] in Islamic boarding schools UW, AT, and SYH. This confirms previous findings in Pakistan that students who lived in dormitories of boarding schools had a higher proportion of anemia compared to those who were day students.[24] Another study found that female students living in university dormitories in Sri Lanka were more likely to experience mild (17.5%) and moderate anemia (7.9%).[25]

We found that students who lived in inadequate environments had better nutritional intake (iron, protein, and vitamin C) than those with adequate environments. A study in Peru reported that healthy eating habits in youth were influenced by the nature of foods available in the physical environment, including at home and schools.[26] Despite the lack of environmental quality, the boarding schools might provide a better menu at the schools' cafeteria, resulting in healthier food choices among adolescent girls. It offered good settings for improving healthful nutrition opportunities, leading to better nutritional intake in girls with inadequate environmental conditions.

On the other hand, although the girls who lived in inadequate environments had better nutritional intake than those with adequate environments, their hematological parameters were not differed significantly. It might be due to considerably lower nutritional intake compared to RDA among those two groups, thus not affecting anemia status indicated by hematological values. The mean iron intake was 5.3 mg/day for girls with adequate environments and 7.3 mg/day for those with inadequate environments, which are lower than the daily intake stated in the Indonesian RDA of 8 mg and 15 mg for females aged 10–12 years and 13–18 years, respectively.[27] Protein intake recommended in RDA was 55 g/day for females aged 10–12 years and 65 g/day for those aged 13–18 years, whereas the female students in the present study consumed only 25.6 g/day and 31.6 g/day protein for those living in adequate and inadequate environments, respectively. Lack of iron intake could affect the synthesis of hemoglobin and the formation of heme enzymes. Meanwhile, the function of protein in the human body is closely related to iron since iron mainly exists in complex forms bound to protein (hemoprotein) as heme compounds (hemoglobin or myoglobin), heme enzymes, or nonheme compounds (flavin-iron enzymes, transferring, and ferritin).[28] Vitamin C intake among the adolescent girls was far below the recommendation of 50-75 mg/day, both in adequate (2.1 mg/day) and inadequate environments (3.9 mg/day), when it is the only absorption enhancer of nonheme iron. The traditional diet in the area of study is a plant-based diet, which is

the main source of nonheme iron,[22] thus low vitamin C intake could reduce iron absorption in the diet and affect their hematological values.

In the present study, we considered 7 Islamic boarding schools in Indonesia and found that for most, the hygienic conditions of bathroom facilities located inside the dormitory buildings did not meet standardized ratios of bathroom users stated by the WHO, which should be a maximum of 25 people for each bathroom. Women who shared a toilet with more than five other people and had inadequate latrine facilities are more prone to parasite infections, resulting in a higher prevalence of anemia.[29,30]

Unclean environmental conditions are often associated with the increased prevalence of infectious diseases, leading to increased incidence of anemia. This finding was consistent with a previous study in Sudan, which found a significant association between the incidence of anemia among students in public dormitories and the prevalence of infectious diseases such as typhus, intestinal worms, and dysentery.[31] Handwashing facilities that offer clean running water and soap in Islamic boarding schools could be a factor that affects handwashing practices, particularly handwashing before eating and after using the toilet. Worm infections can be introduced via unclean fingernails and fingers, such that adequate handwashing could decrease the incidence of infection and prevent infection with parasites that can interfere with iron absorption.[32] Indeed, one study showed that the incidence of anemia was lower in children whose residence had a designated place for handwashing (87.7%) than those that had none (92.4%).[33] Furthermore, the rate of intestinal parasite infection was higher (48.5%) in those who did not practice handwashing compared to those who did.[9]

Bedroom conditions affect the incidence of acute respiratory infection (ARI), which is also related to anemia. Anemic children are more likely to contract respiratory tract infections.[34,35] Other risk factors for ARI include the condition of bedrooms, ventilation, smoke holes in the kitchen, family members who smoke, occupancy density, physical activity or sports, awareness of family nutrition, and the presence of animal cages in the house.[36] The risk of ARI was higher for military trainees who lived in barracks designed to house 60 people than those who lived in rooms that could house eight people.[37] Overcrowding of rooms, which allotted less than 10 sq. ft. per person, could lead to a high prevalence of anemia among girls.[38] In addition, unclean bedrooms in Islamic boarding schools might increase the incidence of bed bugs *(Cimex lectularius)* associated with poor hygiene and high population density.[39,40] Bed bugs are more attracted to dirty clothes than clean clothes, and the occupancy density of bedrooms can increase CO_2 levels that also attract bed bugs.[41] Infestations with bed bugs, which feed on human blood, are also associated with the incidence of anemia. Individuals affected by bed bugs had lower hematological values (hemoglobin, hematocrit, red blood cell count, and MCHC) than those who were not, while RDWCV values were higher for those with bed bugs than those without.[42]

The limitation of this study was that there was no analysis of infectious disease variables, which are a direct impact of poor environmental conditions. Additionally, the study was conducted amid the COVID-19 pandemic, resulting in a few Islamic boarding schools that approved data collection and might not represent the population. It is suggested to analyze the history of infectious diseases using more samples for further study.

Conclusions

Students who lived in poor environmental conditions had a higher nutritional intake of iron, protein, and vitamin C compared to those with adequate environments. Nevertheless, we found no differences in their hematological parameters (Hb, Ht, MCV, MCH, MCHC, and RDWCV). We assume that a similar range of hematological values among girls in different environmental conditions could be related to their poor nutritional intake, which was considerably lower than RDA, and thus it did not significantly affect anemia status. Hence, increasing the quality and quantity of nutritional intake, particularly iron, protein, and vitamin C could prevent anemia among adolescent girls at Islamic boarding schools.

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Conflict of Interest

The authors have no conflicts of interest associated with the material presented in this paper.

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