KORESPONDENSI JURNAL

Judul Artikel	:	Differences in Hematological Parameters and Nutritional Intake Based on Environmental Condition in the Islam Boarding Schools
Penulis	:	**Mohammad Zen Rahfiludin**, Tri Joko, Alfi Fairuz Asna, Septo Pawelas Arso, Lilik Hidayanti
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1. SUBMIT

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2. EDITORIAL COMMENTS

Komentar TIM Editor   ✕

Participants

Haerawati Idris (haera)

Amrina Rosyada (amrina_93)

Mohammad Zen Rahfiludin (rahfiludin615715)

Messages	
Note	From
Pendahuluan Karena peneliti meneliti hubungan lingkungan dan anemia dimana perlu variabel perantara, tidak bisa langsung berhubungan. Sebaiknya disertakan data dari penelitian atau riset terdahulu tentang hubungan perantara ini untuk memperkuat urgensi masalah **Method** Peneliti sebaiknya menyebutkan indicator lingkungn bersih atau tidak itu dari standar apa, karena klo hanya persepsi dari pengumpul data dapat berbeda antara satu	amrina_93 2021-10-13 07:57

3. UPLOAD REVISI EDITOR

▸ Yth. Tim Editor,

rahfiludin615715
2021-10-16 01:57

Berikut perbaikan yang kami susun berdasarkan rekomendasi:

1. Pendahuluan

Data dari penelitian terdahulu terkait penyakit infeksi sebagai variabel perantara sudah ditambahkan.

2. Metode

Metode observasi sudah dijelaskan lebih detail. Sementara no. uji etik sudah dicantumkan dalam manuskrip.

3. Hasil

Mengingat metode yang digunakan adalah observasi lingkungan, maka analisis yang dilakukan pada draft terdahulu hanya analisis univariat. Uji hubungan (misalnya chi square) tidak memungkinkan untuk dilakukan karena terbatasnya jumlah sampel (hanya 7 pondok pesantren), yang kemudian kami jelaskan di bagian Discussion (paragraf terakhir) sebagai keterbatasan penelitian. Namun, sesuai saran untuk melakukan uji bivariat, kami menambahkan hasil analisis uji beda menggunakan Mann-Whitney. Hasil analisis tersebut dibahas lebih lanjut di bagian Discussion.

4. COMMENTS REVIEWER 1

[JIKM] Editor Decision

2021-10-25 07:15

Mohammad Zen Rahfiludin, Tri Joko, Alfi Fairuz Asna, Septo Pawelas Arso, Lilik Hidayanti:

We have reached a decision regarding your submission to Jurnal Ilmu Kesehatan Masyarakat, "ENVIRONMENTAL CONDITION AND INCIDENCE OF ANEMIA IN FEMALE STUDENTS AT ISLAMIC BOARDING SCHOOLS IN WEST JAVA, INDONESIA".

Our decision is: Revisions Required

Reviewer A:
Recommendation: Revisions Required

IRON, PROTEIN, AND VITAMIN C INTAKE IMPROVES ANEMIA STATUS OF FEMALE STUDENTS LIVING IN AN INADEQUATE ENVIRONMENTAL CONDITION[A1]

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ABSTRACT

One problem faced by Indonesian adolescents is micronutrient deficiency. In Indonesia, around 12% of boys and 23% of girls experience anemia, mostly due to iron deficiency anemia (IDA). This study aimed to determine how environmental conditions at Islamic boarding schoolsin Indonesia are related to the incidence of anemia among female students. 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 blood tests to determine hemoglobin (Hb) levels, hematocrit (Ht) levels, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin (MCHC).Nutritional intake data (iron, protein, and vitamin C) was obtained using using 24-hr dietary recall. Environmental conditions were assessed by observations of the boarding school environment including the condition of the kitchen, bedrooms, toilet/bathrooms, and the outside environment including 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 = 0.001), protein (p = 0.006), and vitamin C (p = 0.004) than those who lived in adequate environment.In this study, anemia might not associated with the environmental factors. Instead, nutritional intake played a significant role in determining anemia status among female students in Tasikmalaya, West Java.

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

ABSTRAK

Salah satu masalah yang dihadapi remaja Indonesia adalah defisiensi gizi mikro. Di Indonesia, terdapat sekitar 12% anak laki-laki dan 23% anak perempuan yang mengalami anemia defisiensi besi (IDA). Tujuan penelitian ini adalah menentukan bagaimana pengaruh faktor lingkungan terhadap kejadian anemia pada remaja putri. [A2]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 sampel darah untuk mengetahui kadar hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH),dan mean corpuscular hemoglobin (MCHC). Data asupan zat gizi (besi, protein dan vitamin C) diperoleh melalui metode recall 24 jam. 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*= 0.001), protein (*p* = 0.006), dan vitamin C (*p* = 0.004) yang lebih tinggi daripada santriwati yang tinggal di lingkungan yang baik.Dalam penelitian ini, anemia mungkin tidak berhubungan dengan faktor lingkungan dan asupan zat gizi lah yang berperan penting dalam menentukan status anemia pada santriwati di Tasikmalaya, Jawa Barat.

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

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-oldwas 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 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, and low iron absorption can result in iron deficiency and 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 increasedrate 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 health and well-being of adolescent girls in Indonesia.[9]

To maintain the health of young women and avoid anemia, nutritional interventions are needed. Overcoming nutritional deficiencies can be achieved with multi-sector cooperation through nutrition improvement interventions in the form of both special and sensitive nutrition interventions. Special nutrition interventionsby the health sector represent a direct effort to prevent and reduce nutritional problems.Efforts should be focused on promoting the consumption of iron-rich foods (e.g., meat, fish, and poultry, legumes and green leafy vegetables) and foods that enhance iron absorption.[10]Sensitive nutrition interventions,such as environmental health interventions, are indirect efforts taken by the non-health sector to prevent and reduce nutritional problems.[11]

The environment is a factor associated with the incidence of anemia. Lack of nutrients such as iron and vitamins might be caused by infectious diseases, such as hookworm infestation and malaria, that can be promoted by poor environmental conditions.[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 where predictors of anemia include infectious diseases, length of menstruation, BMI according to age, household monthly income, and number of family members.[15] Sunuwaret al.considered seven countries in South and Southeast Asia and also showed that environmental factors can contribute to the incidence of anemia.[16]Here we examined how environmental conditions in Islamic boarding schools in Indonesia are related to the incidence of anemia among female students.

Method

This descriptive study had a cross-sectional design and was conducted in seven Islamic boarding schools. A total of 167 students were enrolled andthe study was conducted in August 2020. 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.[17]A 24-hour dietary recall method was used to record the daily meal the students received at the school cafeteria and also food or snacks bought outside of school. Food intake was recorded in the form of household portions (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 Islamic boarding schools that were examined included the condition of bathrooms/toilets, kitchens, bedrooms, and outside environment (e.g., trash cans and handwashing facilities) and were assessed through observations of the school environment. The collected data were edited, coded, and entered for data cleaning. Data was analyzed statistically using SPSS software version 23. Descriptive data are presented in the form of frequency distribution tables. The Mann-Whitney test was used to analyze differences in hematological parameter (Hb, Ht, MCV, MCH, MCHC, and RDWCV)and nutritional intake based on the category of environmental condition (adequate and inadequate).The data was obtained by trained enumerators and one person was allocated to observing environmental conditions, so differences in perceptions could be

131 avoided. The blood sampleswere examined byProdia Laboratory. This studypassed ethical review

132 by the Ethics Commission for Health Research, Faculty of Public Health, Diponegoro

133 University(No. 29/EA/KEPK-FKM/2020). Although field study was conducted during the COVID-

134 19 pandemic, researchers were allowed to enter areas of the Islamic boarding schools because they

135 were in the green zone and health protocols were implemented throughout the process of data

136 collection.

137

138 **Results**

139 **Anemia in Female Students**

140　　The students in this study were between 12- and 20-years-old. Hb level was used as an indicator

141 of anemia. Ht levels, MCV, MCH, and MCHC were indicators of iron deficiency anemia (IDA).

142 The AT and SLH boarding schools had the highest and lowest proportion of students withanemia at

143 57.1% and 19%, respectively (Table 1). Female students who experienced anemia in the AT

144 boarding school were found to have IDA (42.9%), while the AI boarding school had the lowest

145 proportion of students withIDA (11.8%) (Table 2).

146

147　　　　　　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%)

148

149　　　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%)

150　　The SLH school had the highest mean ± SD of Hb, Ht, MCV, and MCH of 12.71 ± 1.32 g/dL,

151 38.65 ± 3.09%, 83.6 ± 4.94 fL, and 27.48 ± 2.39pg,respectively. The AT school, in addition to

152 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 ± 4.73pg,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 lowest mean ± SD RDWCV was measured at the SLH Islamic boarding school (13.34 ± 1.59%) (Table 3).

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

		10.3	13.8	12.40±.77
	Hb (g/dL)			
	Ht (%)	33.1	42.0	38.32±2.08
AN	MCV (fL)	25	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 atIslamic boarding schoolsincluded 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. Factors forthe kitchen environment that were evaluated included the 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. The bedroom environment included the type of bedding, type of flooring, ventilation, lighting and the presence of hanging clothes. Characteristics of the external environment that were evaluatedincluded 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. Thebathroom 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 firewood was used to cook rice. The bedroomswere 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). 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 condition. However, dietary intake of iron (p = 0.001), protein (p = 0.006), and vitamin C (p = 0.004) was higher in students with inadequate environment compared to those who lived in an adequate environment (Table 5).

Table 4. Islamic boarding school environmental conditions[A3]

	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

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

193

194 Table 5. Hematological parametersand nutritional intakeof adolescent girls at Islamic boarding
195 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[A4]

196
197
198 **Discussion**

199 This study discovered that living conditionscan affect the proportion of anemia and IDA among
200 students living in Islamic boarding schools in Indonesia.A previous study found that students who
201 lived in dormitories of boarding schools had a higher proportion of anemia compared to those who
202 were day students.[18]Another study found that female students living in university dormitories in Sri
203 Lanka were more likely to experience mild (17.5%) and moderate anemia (7.9%).[19]There was no
204 significant difference between the hematological parameters of students who lived in Islamic
205 boarding schools with adequate environmental conditions and those who lived in inadequate
206 environments.Apparently, those who lived in inadequate environments had better nutritional intake
207 (iron, protein, and vitamin C) than those with adequate one and thus might help improve their
208 hematological values and protect them from anemia and IDA. It was in line with our previous study
209 in rural and urban areas of Central Java, in which nutritional intake, particularly iron, affected
210 hemoglobin and serum transferrin receptor (STfR) levels.[20] A study in Japanese women reported
211 lower incidence of iron deficiency among those who had higher protein intake, mostly from
212 animal-based food since it could increase non heme iron absorption that had lower
213 bioavailability.[21]Iron metabolism was also closely related to vitamin C intake. Vitamin C enhances
214 iron bioavailability by maintaining non-heme iron in the ferrous state and promotes duodenal ferric
215 reductase activity.[22]

7

216   In our study, we considered 7 Islamic boarding schools in Indonesia and found that for most, the
217 hygienicconditions of bathroom facilities located inside the dormitory buildings did not meet
218 standardized ratios of bathroom users stated by the WHO, which should be maximum of 25 people
219 for each bathroom.[23] In Mongolia, schools are recommended to allocate one dormitory bathroom
220 for every 20 students and separate bathrooms should be provided for women and men.[24]Women
221 who shared a toilet with more than five other people are more prone to parasite infections,[25] which
222 is consistent with a study ineastern Africa that reported a higher prevalence of anemia among
223 women who live in households with inadequate latrine facilities.[26]

224   Unclean environmental conditions are often associated with increased prevalence of infectious
225 diseases, which can lead to increased incidence of anemia. This finding was supported by another
226 study that reported a relationship between the incidence of anemia among students in public
227 dormitories and the prevalence of infectious diseases such as typhus, intestinal worms and
228 dysentery.[27]Handwashing facilities that offer clean running water and soap in Islamic boarding
229 schools could be a factor that affects handwashing practices, particularly handwashing before
230 eating and after using the toilet.Worm infections can be introduced via unclean fingernails and
231 fingers, such that adequate handwashing could decrease the incidence of infection and prevent
232 infection with parasites that can interfere with iron absorption.[28]Indeed, one study showed that the
233 incidence of anemia was lower in children whose residence had a designated place for
234 handwashing (87.7%) compared to those that had none (92.4%).[29]Furthermore, the rate of intestinal
235 parasite infection was higher (48.5%) in those who did not practice handwashing compared to
236 those who did.[9]

237   Bedroom conditions affect the incidence of acute respiratory infection (ARI), which is
238 alsorelated to the incidence of anemia.Anemic children are more likely to contract respiratory tract
239 infections.[30,31]Other risk factors for ARI include the condition of bedrooms, ventilation, smoke
240 holes in the kitchen, family members who smoke, occupancy density, physical activity or sports,
241 awareness of family nutrition, and the presence of animal cages in the house.[32]The risk of ARI was
242 higher for military trainees who lived in barracks designed to house 60 people compared to those
243 who lived in roomsthat could house 8 people.[33]Meanwhile, overcrowding of rooms that allotted
244 less than 10 sq. ft. per person was seen in a social welfare hostel that had ahigh prevalence of
245 anemia among girls.[34]In addition, unclean bedrooms in Islamic boarding schools might increase the
246 incidence of bed bugs*(Cimex lectularius)*that can be associated with poor hygiene and high
247 population density.[35,36] Bed bugs are more attracted to dirty clothes than clean clothes, and the
248 occupancy density of bedrooms canincrease CO_2levels that alsoattractbed bugs.[37]Infestations with
249 bed bugs, which feed on human blood, are also associated with incidence of anemia. Individuals
250 thatare affected by bedbugs had lower hematological values (hemoglobin, hematocrit, red blood

cell count, and MCHC) than those who were not, whereasRDWCV values were higher for those with bed bugs than those without.[38]

The use of firewood for cooking at boarding schools can also have health impacts. Cooking over wood firesproduces gases and particulate matter that is damaging to the respiratory system, particularly that of women and children.[39] A higher prevalence of ARI in children was indeed demonstrated among those who live in a household that used wood rather than gas stoves to cook.[40]

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

The AT Islamic Boarding school had the highest prevalence of female students with anemia (57.1%) and IDA (42.9%) with mean ± SD Hb, Ht, MCV, MCH, and MCHC readings of11.47 ± 1.79 g/dL, 35.73 ± 4.34%, 74.4 ± 12.08 fL, 23.9 ± 4.73 pg, and 32.0 ± 1.39 g/dL, respectively. The UW school had the second-highest rate of IDA, and the most students (n=50) of the 7 schools studied. The environmental conditions at the UW school were the poorest of the schools evaluated as reflected by unclean kitchens and bedrooms, inadequate bathrooms, andlack of facilities for handwashing.Nevertheless,we found no differences in hematological parameters (Hb, Ht, MCV, MCH, MCHC, and RDWCV) among female students with adequate and inadequate environmental conditions. Interestingly, students who lived in poor environmental conditions had a higher nutritional intake of iron, protein, and vitamin C compared to those with adequate environments. We assume that nutritional intake played a significant role in improving anemia and IDA status in female students with inadequate environmental conditions in Islamic boarding schools in Tasikmalaya, West Java.

Conflict of Interest

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

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5. COMMENTS REVIEWER 2

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Amrina Rosyada (amrina_93)

Mohammad Zen Rahfiludin (rahfiludin615715)

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

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ABSTRACT

Anemia and iron deficiency anemia (IDA) are health problems affecting adolescent girls in Indonesia and 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 blood tests to determine hemoglobin (Hb) levels, hematocrit (Ht) levels, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) andmean corpuscular hemoglobin (MCHC).Nutritional intake data (iron, protein, and vitamin C) was obtained using 24-hr dietary recall. Environmental conditions were assessed by observations of the boarding school environment including the condition of the kitchen, bedrooms, toilet/bathrooms, and the outside environmentincluding 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 = 0.001), protein (p = 0.006), and vitamin C (p = 0.004) 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) merupakan masalah yang seringkali dihadapi remaja putri di Indonesia. Faktor lingkungan menjadi penyebab tidak langsung terjadinya anemia. Meskipun demikian, 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 pesentren 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 sampel darah untuk mengetahui kadar hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV),

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mean corpuscular hemoglobin (MCH),dan mean corpuscular hemoglobin (MCHC). Data asupan zat gizi (besi, protein dan vitamin C) diperoleh melalui metode recall 24 jam. 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 ($p = 0.001$), protein ($p = 0.006$), dan vitamin C ($p = 0.004$) yang 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.

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 oldwas 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 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, and low iron absorption can result in iron deficiency and 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 increasedrate of miscarriage and maternal mortalityas 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 health and well-being of adolescent girls in Indonesia.[9]

To maintain the health of young women and avoid anemia, nutritional interventions are needed. Overcoming nutritional deficiencies can be achieved with multi-sector cooperation through nutrition improvement interventions in the form of both special and sensitive nutrition interventions. Special nutrition interventionsby the health sector represent a direct effort to prevent

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and reduce nutritional problems. Efforts should be focused on promoting the consumption of iron-rich foods (e.g., meat, fish, and poultry, legumes and green leafy vegetables) and foods that enhance iron absorption.[10] Sensitive nutrition interventions, such as environmental health interventions, are indirect efforts taken by the non-health sector to prevent and reduce nutritional problems.[11]

The environment is a factor associated with the incidence of anemia. Lack of nutrients such as iron and vitamins might be caused by infectious diseases, such as hookworm infestation and malaria, that can be promoted by poor environmental conditions.[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 where predictors of anemia include infectious diseases, length of menstruation, BMI according to age, household monthly income, and number of family members.[15] Sunuwar et al. considered seven countries in South and Southeast Asia and also showed that environmental factors can 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 to date examining nutritional intake and hematological indicators of anemia based on different environmental conditions in the Islamic boarding schools. Therefore, the present 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 seven Islamic boarding schools. A total of 167 students were enrolled and the study was conducted in August 2020. 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] A 24-hour dietary recall method was used to record the daily meal the students received at the school cafeteria and also food or snacks bought outside of school. Food intake was recorded in the form of

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household portions (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 Islamic boarding schools that were examined included the condition of bathrooms, toilets, kitchens, bedrooms, and outside environment (e.g., trash cans and handwashing facilities) and were assessed through observations of the school environment. A score of 1 to 4 was given for each environmental indicator observed, thus the maximum total score was 20. Islamic boarding schools with total score ≥10 were categorized as adequate environment, whereas those with total score <10 were categorized as inadequate environment. Based on the total score, Islamic boarding schools UW and SBH (a total of 82 people) had adequate environment, while the other five Islamic boarding schools, which were AT, SYH, SLH, AI, and AN (a total of 85 people), had inadequate environment. The grouping of the scoring results was applied because it was not possible to statistically analyze the correlation between the environmental conditions of Islamic boarding schools and anemia as the number of Islamic boarding schools was only 7.

The collected data were edited, coded, and entered for data cleaning. Data were analyzed statistically using SPSS software version 23. Descriptive data are presented in the form of frequency distribution tables. 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 data was obtained by trained enumerators and one person was allocated to observing environmental conditions, so differences in perceptions could be avoided. The blood samples were examined by Prodia Laboratory. 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 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 health protocols were implemented throughout the process of data collection.

Results

Anemia in Female Students

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). 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%) (Table 2).

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172 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%)

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174 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%)

175 The SLH school had the highest mean ± SD of Hb, Ht, MCV, and MCH of 12.71 ± 1.32 g/dL,

176 38.65 ± 3.09%, 83.6 ± 4.94 fL, and 27.48 ± 2.39pg,respectively. The AT school, in addition to

177 having the highest incidence of anemia, also had the lowest mean ± SD for Hb, Ht, MCV, and

178 MCH of 11.47 ± 1.79 g/dL, 35.73 ± 4.34%, 74.4 ± 12.08 fL, and 23.9 ± 4.73pg,respectively. The

179 highest and lowest mean ± SD MCHC was seen for AI (33.07 ± 1.30 g/dL)and AT (32 ± 1.39 g/dL)

180 schools, respectively. The highest mean ± SD RDWCV was found at the AT Islamic boarding

181 school (15.03 ± 3.21%)and the lowest mean ± SD RDWCV was measured at the SLH Islamic

182 boarding school (13.34 ± 1.59%) (Table 3).

183

184 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

Comment [f56]: It appears that you are missing a comma before the coordinating conjunction *and* in a compound sentence. Consider adding a comma.

Comment [f57]: This sentence appears to be written in the passive voice. Consider writing in the active voice.

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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 atIslamic boarding schoolsincluded 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. Factors forthe kitchen environment that were evaluated included the 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. The bedroom environment included the type of bedding, type of flooring, ventilation, lighting and the presence of hanging clothes. Characteristics of the external environment that were

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evaluated included 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. Thebathroom conditions were not adequateas 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 uncleanand firewood was used to cook rice. The bedroomswere 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). 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 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.

Table 5. Hematological parametersand 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

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Comment [f60]: This sentence appears to be written in the passive voice. Consider writing in the active voice.

Comment [f61]: It seems that there is an article usage problem here. Consider adding an article: "the".

Comment [f62]: It seems that you are missing a comma. Consider adding a comma.

Comment [f63]: It appears that you are missing a comma before the coordinating conjunction **and** in a compound sentence. Consider adding a comma.

Comment [f64]: Consider rewriting this sentence in the active voice. You'll need to fill in who or what is performing the action.

Comment [f65]: It appears that you have used the single-word verb or the verb phrase **cook** with a word that is usually followed by a prepositional phrase. Consider replacing **to** with a preposition and changing the verb(s) into gerund(s) (-ing form). Consider to change it into: "for cooking".

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. Severe anemia prevalence was reported in Islamic boarding schools UW, AT, and SYH, in which the percentage was more or equal to 40%.[23] This finding was supported by a study in Pakistan in which 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 Canada reported that healthy eating habits in youth were influenced by the nature of foods available in the physical environment, including at home, schools, and in fast-food establishments.[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.Another study found that social support and modeling, availability, and accessibility of healthy and less healthy foods were important for nutrition behaviors.[27] In this case, boarding schools 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 had no significant difference. 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.[28] 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),

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heme enzymes, or nonheme compounds (flavin-iron enzymes, transferring, and ferritin).[29] 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 isa plant-based diet, which is the main source of nonheme iron,[30] thuslow vitamin C intake could reduce iron absorption in the diet and affectedtheir hematological values.

In the present study, we considered 7 Islamic boarding schools in Indonesia and found that for most, the hygienicconditions of bathroom facilities located inside the dormitory buildings did not meet standardized ratios of bathroom users stated by the WHO, which should be maximum of 25 people for each bathroom.[31] In Mongolia, schools are recommended to allocate one dormitory bathroom for every 20 students andseparate bathrooms should be provided for women andmen.[32]Women who shared a toilet with more than five other people are more prone to parasite infections,[33] which is consistent with a study ineastern Africa that reported a higher prevalence of anemia among women who live in households with inadequate latrine facilities.[34]

Unclean environmental conditions are often associated with increased prevalence of infectious diseases,which can lead to increased incidence of anemia. This finding was supported by another study that reported a relationship between the incidence of anemia among students in public dormitories and the prevalence of infectious diseases such as typhus, intestinal worms and dysentery.[35]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.[36]Indeed, one study showed that the incidence of anemia was lower in children whose residence had a designated place for handwashing (87.7%) compared to those that had none (92.4%).[37]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 alsorelated tothe incidence of anemia.Anemic children are more likely to contract respiratory tract infections.[38,39]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.[40]The risk of ARI was higher for military trainees who lived in barracks designed to house 60 peoplethan those who lived in roomsthat could house 8 people.[41]Meanwhile, overcrowding of rooms that allotted less than 10 sq. ft. per person was seen in a social welfare hostel that had ahigh prevalence of anemia among girls.[42]In addition, unclean bedrooms in Islamic boarding schools might increase the incidence

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ofbed bugs*(Cimex lectularius)*that can be associated with poor hygiene and high population density.[43,44] Bed bugs are more attracted to dirty clothes than clean clothes, and the occupancy density of bedrooms canincrease CO_2levels that alsoattractbed bugs.[45]Infestations with bed bugs, which feed on human blood, are also associated with incidence of anemia. Individualsthatare affected by bedbugs had lower hematological values (hemoglobin, hematocrit, red blood cell count, and MCHC) than those who were not, whereasRDWCV values were higher for those with bed bugs than those without.[46]

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

Mohammad Zen Rahfiludin[1*], Tri Joko[2], AlfiFairuz Asna[1], SeptoPawelas Arso[3], Lilik Hidayanti[4]

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ABSTRACT

Anemia and iron deficiency anemia (IDA) are health problems affecting adolescent girls in Indonesia and 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 blood tests to determine hemoglobin (Hb) levels, hematocrit (Ht) levels, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH,) and mean corpuscular hemoglobin (MCHC). Nutritional intake (iron, protein, and vitamin C) was determined using a 24-hr dietary recall. 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 = 0.001), protein (p = 0.006), and vitamin C (p = 0.004) 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.*

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ABSTRAK

Anemia dan anemia defisiensi besi (IDA) merupakan masalah yang seringkali dihadapi remaja putri di Indonesia. Faktor lingkungan menjadi penyebab tidak langsung terjadinya anemia. Meskipun demikian, 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 pesentren 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 sampel darah untuk mengetahui kadar hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), dan mean corpuscular hemoglobin (MCHC). Data asupan zat gizi (besi, protein dan vitamin C) diperoleh melalui metode recall 24 jam. 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 = 0.001), protein (p = 0.006), dan vitamin C (p = 0.004) yang 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.

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

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 $\leq 36\%$ is considered to be abnormal. The threshold valuesfor 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). 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%) (Table 2).

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%)

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%)

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 forHb, 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%) (Table 3).

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

	Hb (g/dL)		10.3	13.8	12.40±.77
	Ht (%)		33.1	42.0	38.32±2.08
AN	MCV (fL)	25	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). 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 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.

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 Canada reported that healthy eating habits in youth were influenced by the nature of foods available in the physical environment, including at home, schools, and in fast-food establishments.[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. Another study found that social support and modeling, availability, and accessibility of healthy and less healthy foods were important for nutrition behaviors.[27] In this case, boarding schools 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.[28] 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).[29] 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,[30] 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.[31] In Mongolian schools, women and men have separate bathrooms, and every 20 students shared one bathroom to use.[32] 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.[33,34]

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.[35]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.[36] 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%).[37] 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.[38,39] 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.[40] 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.[41] Overcrowding of rooms, which allotted less than 10 sq. ft. per person, could lead to a high prevalence of anemia among girls.[42] In addition, unclean bedrooms in Islamic boarding schools might increase the incidence of bed bugs *(Cimexlectularius)* associated with poor hygiene and high population density.[43,44] 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.[45] 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.[46]

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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