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The Association of Clean and Healthy Living Behavior along with Hemoglobin and Serum Ferritin Levels among Adolescent Girls

Hubungan Perilaku Hidup Bersih dan Sehat dengan Kadar Hemoglobin dan Feritin Serum pada Remaja Putri

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ABSTRACT

Background: Clean and healthy life behavior that is not appropriately implemented will cause various infectious diseases that trigger anemia. Islamic boarding schools have a significant role in instilling clean and healthy life behavior in students.
Objectives: This study aimed to analyze the relationship between pure and healthy life behavior with hemoglobin and serum ferritin. Hemoglobin and serum ferritin are indicators for diagnosing iron deficiency anemia.
Methods: The research design was a cross-sectional study conducted in January – February 2021 at the Al Falak Islamic Boarding School in Bogor. A total of 45 subjects were selected with inclusion criteria, namely students aged 12-20 years, in good health, and being in the dormitory during the study period, while the exclusion criteria were not being in the dormitory for more than two weeks. Anaemia data status was obtained by measuring hemoglobin and serum ferritin levels. Analysis of hemoglobin (Hb) levels used the Cyanmethemoglobin method, while the analysis of ferritin levels in serum samples used the Chemiluminescent Microparticle Immunoassay (CMIA) way. Analysis of the correlation between the dependent variable, namely hemoglobin and serum ferritin, and the independent variable, namely clean and healthy living behavior.
Results: Based on the hemoglobin value, 37.8% of the subjects had anemia, while based on the serum ferritin value, as much as 51.1% of the subjects had low iron status. Behavior related to personal hygiene, conduct related to washing hands, and behavior associated with the cleanliness of the subject's residence was classified as good, respectively, at 55.6%, 57.8%, and 44.4%. There was a correlation between personal hygiene-related behavior with hemoglobin (p= 0.042) (r=0.305) and serum ferritin (p= 0.036) (r=0.313).
Conclusions: Personal hygiene was related to hemoglobin and ferritin serum in adolescent girls due to maintaining a clean and healthy life in Islamic boarding schools, primarily associated with personal hygiene.

INTRODUCTION

Adolescence is a period in the human life cycle where several physical, social, and psychological changes can trigger changes in eating behavior[1]. The nation's future depends on youth with optimal intelligence and health. Adolescents commonly suffer health problems, such as abnormal nutritional status, low hemoglobin levels, and psycho-social disorders[2]. Female adolescents are susceptible to anemia because of weight gain, rapid growth, and increased blood volume during this period. They also have menstruation, as growth in young women occurs earlier than in young men.

Anemia in adolescents will affect their learning ability, cognitive function, and health status. In young women, anemia affects their current health status and has future adverse effects. If the anemia is suffered until the young woman eventually grows up and has children, there will be a risk of premature birth and infant death in the future[3].

Data from the World Health Organization (WHO) in 2015[4] stated that 2 billion people worldwide suffer from anemia or more than 30% of the world's population. The prevalence of anemia in East and Southeast Asia in 2011 was 25% (aged <5), 21% for women of childbearing age aged 15-49, and 25% for pregnant women aged 15-49[5]. According to Basic Health Research (Riskesdas) data in 2018[6], the prevalence of anemia is 27.2% suffered by women and 20.3% suffered by men, and 32% for the overall population aged 15-32%.

Iron deficiency is a cause of anemia characterized by low levels of serum ferritin and

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hemoglobin. Ferritin levels less than 30 µg/mL indicate low iron in the body. Ferritin levels may increase during inflammation[7]. While hemoglobin levels are less than 13.0 g/dL in men, less than 12.0 g/dL in women, and less than 11.0 g/dL in pregnant women, they are categorized as anemia[8].

The role of Islamic boarding schools in implementing clean and healthy lifestyle behaviors for students is enormous and essential because most of their time is spent in Islamic boarding schools. Clean and healthy lifestyle behavior is a way to keep the body healthy and prevent diseases. Creating and maintaining a healthy environment in Islamic boarding schools can actively improve the surrounding community's health. It is supported by Devi et al.'s research results in 2014, children aged 10-15 years in India found a relationship between anemia and personal hygiene[9].

Research conducted by Manna and Debidas (2017) on female workers in tea gardens in North Bengal found a significant relationship between personal hygiene and anemia. These women workers are not used to bathing regularly, washing their hands before eating, keeping clothes and footwear clean, and cleaning their hair[10]. The incidence of anemia is exacerbated by worm infections caused by the unavailability of clean drinking water. Hygiene practices, clean drinking water, and hygiene maintenance have contributed to reducing the incidence of anemia because it reduces infections caused by parasites (Baranwal et al. 2014)[11]. Maintaining personal hygiene is an integral part of clean and healthy living behavior practices. This study aimed to analyze the relationship between pure and healthy lifestyle behavior with hemoglobin and serum ferritin among students in Al Falak Islamic Boarding School in Bogor, Indonesia.

METHODS

The data from this study was part of the baseline data for the efficacy test of Fe-biofortified rice from molecular breeding in Islamic boarding school students conducted by the Center for Research and Development of Biotechnology and Genetic Resources, Research and Development Center of the Ministry of Agriculture, Indonesia. A cross-sectional study design was done during the study. The place for data collection was the Al Falak Islamic Boarding School in Bogor, held from January to February 2021. Subjects, who were Islamic boarding school students, were selected if they met the inclusion criteria: (1) being active in activities at the Islamic boarding school and coming when blood tests were carried out, (2) being healthy and not sick with fever, diarrhea, tuberculosis, or other diseases during the study, and (3) willing to participate in the study by filling out informed consent. Exclusion criteria were (1) menstruating when the blood test was carried out and (2) not being in the hostel for more than two weeks. The number of selected subjects was 45 people.

The variable studied was clean and healthy living behavior (PHBS). Clean and healthy living is a person's behavior to obtain health that is done consciously and responsibly. Based on The Ministry of Health (2011), PHBS practices in the school environment include avoiding smoking and distributing illegal drugs, adopting a healthy lifestyle, providing adequate toilets and trash cans, and routinely cleaning water reservoirs from mosquito larvae[12]. PHBS in this study was divided into three criteria: (1) behavior related to personal hygiene, (2) behavior related to hand washing, and (3) behavior related to the cleanliness of the residence. PHBS data were collected using a questionnaire adapted from Syukri's research[13]. The PHBS assessment was carried out based on a score with a range of 1-5. Score 1 if the respondent answers "never," score 2 for "rarely," score 3 for "sometimes," score 4 for "often," and score 5 for "always." PHBS assessment categories were divided into 2: "bad" if the value was < median and "good" if the value was ≥ median. The subject's anemia status was measured by serum hemoglobin and ferritin levels. Laboratory tests were conducted in the Prodia laboratory, Bogor. The value of hemoglobin and ferritin levels was obtained from a blood sample from a vein in the arm (median cubital vein or cephalic vein), after which the blood was centrifuged to obtain blood serum. Analysis of hemoglobin (Hb) levels was done using the Cyanmethemoglobin method. WHO states that checking Hb levels using the Cyanmethemoglobin method is very accurate and thorough and is recommended by the International Committee for Standardization in Hematology (ICHS)[14]. The principle of the Cyanmethemoglobin method is that hemoglobin is converted to hemoglobin cyanide which is carried out quantitatively using a reagent solution within 3 minutes, and the color formed is measured using a photometer[15]. Analysis of ferritin levels in serum samples using the Chemiluminescent Microparticle Immunoassay (CMIA) method was carried out in two stages. The first step is mixing the sample and paramagnetic microparticle, which has been coated with anti-ferritin. Firstly, the sample binds to the anti-ferritin, which coats the microparticle. Secondly, wash it and add it with anti-ferritin acridinium labeled conjugate. After that, the pre-trigger and trigger solutions were added to the reaction mixture to produce a chemiluminescent reaction measured as relative light units (RLUs). The amount of ferritin in the sample was proportional to the RLUs detected by the Architect's optical system. The ferritin in the sample binds to the anti-ferritin, which coats the microparticle.

The variables analyzed were the relationship between personal hygiene behavior and serum hemoglobin and ferritin levels, hand washing behavior and serum hemoglobin and ferritin levels, and the relationship between behavior related to residential hygiene and serum hemoglobin and ferritin levels. Statistical analysis used SPSS version 22 software through the Rank Spearman relationship test with a 95% confidence level. This research received approval from the Bogor Agricultural University Ethics Commission with number 335/IT3.KEPMSM-IPB/SK/2021.

RESULTS AND DISCUSSION

Subject Demographics

A Total of 45 subjects (100%) were female, and 17 had iron nutritional anemia. The age of the subjects was in the range of 12-20 years, with an average age of 15 years and two months, divided into three categories: aged 12-15 were early adolescence, 15-18 were middle

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adolescence, and 18-21 were late adolescence[16]. The results showed that most subjects were included in the early adolescent category (64.4%).

Distribution of Subjects Based on Clean and Healthy Behavior Category

The median value of behavior related to personal hygiene was 44. Based on the results of the univariate analysis, it was found that 25 subjects (55.6%) had good personal hygiene-related behavior, and 20 subjects (44.4%) had poor personal hygiene-related behavior. The median value of behavior related to hand washing was 35. Based on the results of the univariate analysis, 26 subjects (57.8%) had good hand-washing-related behavior, and 19 subjects (42.2%) had terrible hand-washing-related behavior. The median value of behavior related to residential hygiene is 48. Based on the results of univariate analysis, 20 subjects (44.4%) had good hygiene-related behavior, and 25 subjects (55.6%) had poor hygiene-related behavior.

Table 1. Distribution of Subjects by Category of Behavior Related to PHBS

Category	Amount	
	n	%
Behavior Related to Personal Hygiene		
Good (Score ≥ median)	25	55.6
Poor (Score < median)	20	44.4
Amount	45	100
Median value	44	
Behavior Related to Hand Washing		
Good (Score ≥ median)	26	57.8
Poor (Score < median)	19	42.2
Amount	45	100
Median value	35	
Behavior Related to Residential Cleanliness		
Good (Score ≥ median)	20	44.4
Poor (Score < median)	25	55.6
Amount	45	100
Median value	48	

Distribution of Subjects based on Clean and Healthy Behavior Habits

This study found that the number of subjects who behaved well regarding personal hygiene was higher than those who misbehaved. This finding related to the excellent awareness of owning and using personal belongings such as toiletries, clothes, and towels. Most subjects could maintain personal hygiene by bathing and cleaning their teeth daily. However, a large percentage of subjects still have bad personal hygiene behavior, which was due to low awareness and knowledge regarding personal hygiene. Research conducted by Lalangpuling (2020) showed a relationship between clean and healthy living behavior and the incidence of worm infections[17]. Meanwhile, the study's results found that helminth infections are associated with the incidence of anemia[18].

Adolescent perceptions of a healthy lifestyle include a good diet, regular physical activity, a good environment, sanitation, and personal hygiene[18,19]. Most Al Falak Islamic Boarding School students had good personal hygiene behavior, which can support a healthy lifestyle among teenagers. Gabur et al. (2017) research on school-age children in Malang showed that personal hygiene is related to clean and healthy living behavior[20]. Improved public health and the risk of spreading communicable diseases can be reduced by adopting personal hygiene practices[21]. Meanwhile, Manna and Debidas (2017) found a relationship between personal hygiene and anemia[10].

The Ministry of Health of Indonesia (2020) stated that washing hands with soap should be done for at least 40-60 seconds. According to the procedure, it has been proven effective in killing germs that cause disease[22]. This study found that the number of subjects with good behavior regarding hand washing was higher than the number of subjects with bad behavior. This finding was related to the hand-washing facilities that Islamic boarding schools have provided. The hand washing facilities are spread around the Islamic boarding school to prevent various diseases and maintain the health of all boarding school residents.

Hands contaminated with harmful microorganisms originating from contaminated surfaces can cause disease transmission to oneself and others. Bacteria, viruses, and parasites that cause disease can be removed by washing hands with soap and water[23]. Alwis et al. (2012) found that the number of bacteria on the hands increased after using the toilet[24]. Meanwhile, research conducted by Manna and Debidas (2017) on young girls and working women in North Bengal showed that clean and healthy living behavior, one of which was maintaining personal hygiene through the practice of hand washing, was not appropriately implemented and was found to be significantly related to the incidence of anemia in area[10].

Behavior related to the residence's cleanliness, especially in the Islamic boarding school environment, is crucial because cleanliness is not only a personal responsibility but also for all residents. This study found that the number of subjects who behaved well related to the cleanliness of their residence was lower than the number of subjects who misbehaved.

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This finding was related to the concern and awareness of students to maintain the cleanliness of Islamic boarding school facilities and infrastructure together. Their bedroom has an area of ± 4 x 6 m, and 13-18 female students occupy each. Schoolgirls often take turns using bedding and picket schedule for cleaning the bedroom.

Self-care, care, and good knowledge regarding the cleanliness of the residence or environment will create a clean environment. A clean environment is an indicator of good hygiene behavior[25]. Islamic boarding school students need to know the importance of clean and healthy living behavior to implement the picket schedule more optimally in the boarding school environment. Research conducted by Ali et al. (2016) showed that 30.8% of children who shared a toilet had worms and low hemoglobin levels (anemia)[26]. Data on the distribution of subjects based on clean and healthy living habits are presented in Table 2 below

Table 2. Distribution of subjects based on clean and healthy behavior habits

Statement	Not once	Seldom	Sometimes	Often	Always
	n (%)	n (%)	n (%)	n (%)	n (%)
Behavior Related to Personal Hygiene					
In one day, shower at least twice	0 (0)	2(4.4)	0 (0)	7 (15.6)	36(80)
Teeth and mouth are cleaned using a toothbrush and toothpaste	0 (0)	0 (0)	0 (0)	5 (11.1)	40(88.9)
Brush your teeth in the morning and at night before going to bed	0 (0)	0 (0)	0 (0)	6 (13.3)	39(86.7)
Toothbrushes are not used interchangeably with friend	16 (35.6)	0 (0)	0 (0)	0 (0)	29(64.4)
Nails are cut regularly	0 (0)	5 (11.1)	11(24.4)	5 (11.1)	24(53.3)
Wash your hair regularly using shampoo	0 (0)	1(2.2)	4 (8.9)	6 (13.3)	34(75.6)
Clothing is not shared with other female students alternate	8 (17.8)	6 (13.3)	7 (15.6)	1(2.2)	23(51.1)
Towels are not shared with other students alternate	15 (33.3)	0 (0)	0 (0)	0 (0)	30(66.7)
Clothes are changed every day	0 (0)	2(4.4)	8 (17.8)	6 (13.3)	29(64.4)
Undergarments are changed every day	0 (0)	1(2.2)	3 (6.7)	2(4.4)	39(86.7)
Behavior Related to Hand washing Habits					
Hands are washed after defecation	0 (0)	0 (0)	0 (0)	2(4.4)	43(95.6)
Hands are washed after urinating	0 (0)	0 (0)	2(4.4)	1(2.2)	42(93.3)
Hands are washed with soap when hands are dirty	0 (0)	0 (0)	3 (6.7)	7 (15.6)	35(77.8)
Hands are washed with soap before handling food or groceries	0 (0)	3 (6.7)	2(4.4)	11(24.4)	29(64.4)
Hands are washed before eating	0 (0)	1(2.2)	1(2.2)	7 (15.6)	36 (80)
Hands are washed after eating	0 (0)	0 (0)	0 (0)	4 (8.9)	41(91.1)
Hands are washed with soap after defecation	0 (0)	2(4.4)	0 (0)	3 (6.7)	40(88.9)
Behavior Related to Residential Cleanliness					
Pee in the toilet	1(2.2)	0 (0)	0 (0)	3 (6.7)	41(91.1)
Defecate in the toilet	1(2.2)	0 (0)	0 (0)	3 (6.7)	41(91.1)
The toilet is flushed after pee	1(2.2)	0 (0)	0 (0)	1(2.2)	43(95.6)
The toilet flushes after defecating	1(2.2)	0 (0)	1(2.2)	1(2.2)	42(93.3)
The toilet floor was brushed and cleaned	1(2.2)	1(2.2)	23 (51.1)	3 (6.7)	15(33.3)
Garbage is not thrown in the toilet	7(15.6)	1(2.2)	3 (6.7)	4 (8.9)	30(66.7)
Regular cleaning of toilets	0 (0)	2(4.4)	13 (28.9)	17(37.8)	13(28.9)
Regular drain tub in the bathroom	1(2.2)	5 (11.1)	12 (26.7)	12(26.7)	15(33.3)
Bedrooms are cleaned regularly	0 (0)	1(2.2)	8 (17.8)	5 (11.1)	31(68.9)
Clean the bed regularly	1(2.2)	1(2.2)	4 (8.9)	5 (11.1)	34(75.6)
Do not use the bed alternately with other girls	11(24.4)	1(2.2)	21 (46.7)	1(2.2)	11(24.4)

Anemia Status

The subject's anemia status was determined based on serum hemoglobin and ferritin levels. The results showed that based on hemoglobin levels, 62.2% of the subjects were in the normal category, 28.9% mild, and 8.9% moderate. Meanwhile, 48.9% were included in the normal category based on serum ferritin levels, and 51.1% were low. Data on the distribution of subjects based on anemia status is presented in Table 3.

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Table 3. Data distribution of subjects based on anemia status

Anemia status	n	%
Hemoglobin		
- Normal	28	62.2
- Mild Anemia	13	28.9
- Moderate Anemia	4	8.9
Total	45	100
Serum Ferritin		
- Normal	22	48.9
- Low	23	51.1
Total	45	100

According to the World Health Organization (WHO), the diagnosis of anemia is if a person has a hemoglobin (Hb) level of <12 g/dL and a serum ferritin level of <50 µg/dl[27]. Serum ferritin reflects iron stores and is the most accurate test for diagnosing iron deficiency anemia[28]. Hamidiyah et al. (2019) study on Islamic boarding school students showed that 79% of female students at the Salafiyah Syafi'iyah Islamic Boarding School Sukorejo Situbondo were anemic because of infectious diseases, light physical activity and consumption of nutrients that do not match the nutritional adequacy rate[29]. Research conducted by Dumilah and Sri (2017) showed that anemia is related to student achievement at school. Anemia can cause a decrease in student concentration and focus[30].

The increased need for iron in young women, if it is not supported by optimal nutritional intake, can cause iron deficiency resulting in anemia which not only affects the health status of young women for now but also has a detrimental effect when a teenager becomes a mother later. Overall health status is assessed from a person's hemoglobin level. A good hemoglobin status at conception will result in safe pregnancy and a healthy child's birth. This condition can be achieved if female adolescents' hemoglobin status increases. Optimal iron status is needed for young women entering the reproductive period[31,32,33]. Iron intake, both from heme and non-heme iron, will determine serum ferritin and hemoglobin levels in the body. Research by Pradanti et al. (2015) on Grade VIII students of SMP Negeri 3 Brebes showed that there was a relationship between iron intake and hemoglobin levels, as well as the results by Ekorinawati (2010) found that iron intake was related to hemoglobin levels in children aged six months to 24 months[34,35]. Arima et al. (2019) conducted a study of young women in Semarang and, from the analysis results, found a significant relationship between iron intake and serum ferritin in female adolescents[36]. Likewise, Ekorinawati (2010) study found that iron intake was related to hemoglobin levels in children aged six months to 24 months[34,35].

Several determinants that significantly contribute to iron deficiency anemia are low iron intake, folic acid, and vitamin B12 (Thomas et al. 2015)[37]. The absorption of iron in the intestine is also influenced by the erythropoietic rate, the storage of iron in the body, namely transferrin and ferritin, and iron availability in food. The availability of iron in food depends on iron sources, such as animal sources (heme) such as meat, poultry, and fish, which have higher bio-availability compared to iron from vegetable sources (non-heme) and the presence of a factor that enhances iron absorption, namely ascorbic acid (vitamin C) and absorption inhibitors, namely tannins (found in tea), phosphates and phytates[38]. The level of adequacy of energy, protein, and iron does not affect nutritional status and anemia (p>0.05) (Fathonah et al. 2014)[39].

Relationship between Clean and Healthy Behavior with Hemoglobin and Serum Ferritin

After the correlation test, it could be concluded that personal hygiene was related to hemoglobin and serum ferritin and has a significance value of 0.042 and 0.036, respectively. Meanwhile, other clean living behavior criteria, such as hand washing behavior and cleanliness of the residence, did not show a significant relationship. The data is presented in detail in Table.

Table 4. Relationship between clean and healthy behavior with hemoglobin and serum ferritin

Variable	*Hemoglobin*		*Ferritin Serum*	
	r	p	r	P
Personal hygiene	0.305*	0.042	0.313*	0.036
Washing hands	0.217	0.152	0.219	0.148
Cleanliness of residence	0.078	0.612	0.181	0.235

The correlation test results on three categories of clean and healthy living behavior with anemia found that one of the categories, personal hygiene behavior, correlated with hemoglobin and serum ferritin. Devi et al. (2014) supported the results of this study in children aged 10-15 years in India that anemia was related to personal hygiene[9]. The dominant factor that supports the personal hygiene of students at Islamic boarding schools is the availability of facilities and infrastructure as well as knowledge, support from friends, boarding school teachers, facilities and health workers as well as regulations that are well enforced through education and supported by the Ministry of Religion[40]. Based on the results of observations and assessments that have been done, Al Falak Islamic Boarding School has a value that is included in the good

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criteria in terms of sanitation for Islamic boarding schools. The facilities and infrastructure provided by the Islamic boarding school are sufficient to support the implementation of a clean and healthy lifestyle for all residents of the boarding school, so it is hoped that this will be one way to prevent disease. What needs attention is the means for washing hands, namely soap which must be provided again immediately after running out. The behavior of washing hands with soap is proven effective in killing germs[25]. The Islamic boarding school's owner monitors the Islamic boarding school's cleanliness online and, at certain times, visits all rooms, including the student rooms, to check the cleanliness and completeness of facilities and infrastructure.

Several respondents' answers to several statements related to personal hygiene, hand washing habits, and cleanliness of the residence sufficiently illustrate how the implementation of PHBS still needs improvement. These include alternating use of toothbrushes, clothes, and towels with friends, washing hands with soap before handling food and after defecation, the habit of throwing garbage in the toilet, alternating use of mattresses/bedding, and routinely draining the bathtub to remove mosquito larvae. Table 5 shows the number of respondents with excellent and bad PHBS based on serum hemoglobin and ferritin values.

Table 5. Number of Respondents with Good and Bad PHBS Based on Serum Hemoglobin and Ferritin Values

Score	*Number of PHBS*	
	Well	**Bad**
Hemoglobin		
Normal (12 g/dL)	28	-
Mild (10-11.9 g/dL)	-	13
Moderate (7-9.9 g/dL)	-	4
Severe (< 7 g/dL)	-	-
Total	28	17
Serum Ferritin		
Normal (10-120 ng/mL)	22	-
Low (<10 ng/mL)	-	23
Total	22	23

The Table shows that the number of respondents who belong to the good PHBS category and had normal hemoglobin values was 2, and normal serum ferritin values were 22. Meanwhile, the number of respondents who were in the wrong category and had mild and moderate hemoglobin values was 17 people, and 23 had low serum ferritin values.

Research on handwashing interventions conducted by Mahmud et al. (2015) on children aged 6-15 found that anemia decreased significantly after six months of handwashing interventions with soap[41]. The possibility of anemia in children who practice handwashing with soap was slighter than in those who do not, which is 61%. The implementation of clean and healthy living behavior has not been maximized due to poor sanitation conditions resulting in anemia. Biomarkers of iron status include hemoglobin, serum ferritin, transferrin, hematocrit, and zinc protopofirin. These biomarkers are affected by inflammation with different mechanisms and impacts[42]. Exposure to pathogenic bacteria in the intestine can cause acute and chronic intestinal infections resulting in enteric and systemic inflammation. Environmental enteropathy (EE) is a subclinical condition in which intestinal inflammation and chronic villous atrophy result in reduced intestinal absorption surface area and decreased nutrient absorption[43]. Exposure to continuous pathogens can also cause systemic inflammation; ultimately, iron in the intestine is not absorbed correctly. Iron decreases, causing iron deficiency anemia[44].

A study by Fattah et al. (2020) and Dewi and Dewa (2017) found that personal hygiene, including handwashing behavior, is associated with helminthiasis[45,46]. WHO (2014) explains that the lower the intake of foods high in iron and the higher the frequency of infections caused by parasitic worms, the higher the risk of suffering from iron deficiency[47]. Research by Aryadnyani et al. (2020) concluded that the higher the infection caused by parasitic worms, the lower the hemoglobin level[48]. Worms cause the nutrients needed by children cannot be adequately absorbed because worms/parasites consume these nutrients, causing delayed physical development and several health problems such as anemia, diarrhea, intestinal obstruction,

Iron deficiency anemia can occur due to decreased iron intake, increased iron requirements, chronic blood loss, or decreased intestinal absorption. Inflammatory cytokines affect iron metabolism. Cytokines stimulate hepcidin production, which causes iron uptake in macrophage stores and decreases circulating transferrin saturation and tissue iron availability. Variable degrees of inflammation characterize several common human disorders, such as atherosclerosis, obesity, diabetes, and metabolic syndrome[7]. Inflammation causes impaired iron absorption so that iron from the circulation is diverted to storage sites in the reticuloendothelial system and limits iron availability to erythroid progenitor cells. In addition, inflammation also reduces plasma retinol, which is helpful for erythropoiesis which causes anemia, by inhibiting iron absorption by erythroblasts and other target tissues that require iron for development, including the muscles and brain of children[49]. The causes of iron deficiency anemia according to age are children

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aged five years to adolescence due to bleeding caused by parasitic infections and polyps causing excessive blood loss. In contrast, in adolescence to adulthood, especially in women, it is caused by excessive menstruation[50].

The advantage of this research was that there were still limited studies on PHBS concerning infection and anemia in Islamic boarding schools, where cases of anemia in adolescents in Islamic boarding schools are pretty high. However, this study had a weakness. The respondent's food intake method uses food recall which depended on the respondent's memory, so it could lead to bias in calculating the amount and type of food consumed in 2x24 hours (on holidays (weekends) and school days (weekdays)). Even so, this deficiency could be minimized by interviewing cooks at Islamic boarding schools regarding the food menu served to respondents.

CONCLUSIONS

Clean and healthy living behavior was essential in Islamic boarding schools to prevent health problems, including anemia. Young women are prone to anemia. Personal hygiene was significantly associated with hemoglobin levels and serum ferritin, while hand-washing behavior and residential hygiene were not significantly associated with hemoglobin levels and serum ferritin. Research with more respondents is needed to prove the correlation between hand-washing behavior and the cleanliness of the residents with hemoglobin and serum ferritin levels in Islamic boarding schools.

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