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Prevalence and Associated Factors of Anemia among Muslim Students, Nakhon Si Thammarat, Thailand: A Cross-Sectional Study

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Abstract

Anemia is a global public health problem. The prevalence of anemia among different ages, genders or ethnic groups must be clarified in order to solve problems. This study proposed to determine the prevalence and factors related to anemia among the Muslim school-age population in Nakhon Si Thammarat, Thailand. Socio-demographic and anthropometric data were collected by a structured questionnaire. Blood samples were collected from 200 school-age subjects. The thalassemia screening was performed with KKU-OF and KKU-DCIP reagents. The prevalence of anemia in this study was 36.5%, divided into males and females, 33.3% and 39.1%, respectively. The means of Hb, Hct, MCV, MCH, and MCHC in the anemic group were significantly lower. The positive results for KKU-OF or KKU-DCIP or both were 15.0%, 2.5%, and 1.0%, respectively. The result of positive OF test was a significantly independent factor for anemia. The number of family members was 5 to 7 and more than 7 persons are related factors for anemia in this study. In summary, the contribution of thalassemia and socio-economic factor are associated factors to anemia in this population. These findings should be addressed in public health strategies for the control of anemia of school-aged Muslims in the region.

Keywords

prevalence, Muslim, ethnic group, public health, Thailand

What do we already know about this topic?
The prevalence and associated factors of anemia in school-age Muslim students in Nakhon Si Thammarat, Thailand.

How does your research contribute to the field?
The results of the study provide encouraging data for public health strategies to control of anemia of Muslim school-age in the region.

What are your research's implications toward theory, practice, or policy?
Our study implications toward the policy.

Introduction

Anemia is an important public health problem characterized by less hemoglobin concentration than normal for age and gender. It is caused by many factors, including genetic disorder in the production of hemoglobin, malnutrition, and infectious or chronic diseases.[1] It affects about 1.62 billion people or corresponds to 24.8% of the population of all ages around the world, especially preschool children, pregnant women, and women of reproductive age.[2] If found in preschool children or school children, it has a direct impact on the growth

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and development of the brain, intelligence, and perception of children who are considered an important resource group in the country. Therefore, each country has determined the appropriate measures to prevent anemia. According to data from the World Health Organization,[3] anemia is highly prevalent in developing countries in Africa and Southeast Asia. The main cause of anemia found in these regions is primarily due to iron deficiency.[3] With the incidence of anemia in Thai children, the nutritional status of Thai children aged 6 months to 12 years was surveyed between 2010 and 2012. The high prevalence of anemia was found in up to 41.7% in rural areas, while 26% in urban children due to many factors, including thalassemia, malnutrition, such as iron that are concurrent with thalassemia, vitamin A deficiency, chronic diseases, and parasitic diseases, such as malaria and hookworm.[4,5] The study of the prevalence of anemia in pregnant Thai Muslim women in the southern region demonstrated that it was 34.4%, 37.8%, and 7.8% of the prevalence of iron deficiency, iron deficiency anemia, and other types of anemia.[6] There was an evidence of higher proportion of anemia in women belonging to the Muslim community (92.3%) compared to non-Muslims (81.1%).[7] Iron deficiency was also the main cause of anemia (13 of 19 cases) in girls in the high school.[8] Regarding to puberty, adolescents require an increased intake of nutrients for rapid growth and physiological development, particularly in women, as menstrual combination can be one of the reasons that lead to anemia.[9] Therefore, the objective of this study was to determine the prevalence and causes of anemia in Muslim secondary school students in Thasala District, Nakhon Si Thammarat Province in southern Thailand.

Materials and Methods

Studied Population

The cross-sectional study was conducted at Panyasaratham School of 200 Muslim students aged 12 to 18 years in Thasala District, Nakhon Si Thammarat Province in southern Thailand. A total of 200 participants were recruited in this study including 90 males and 110 female students. The inclusion criteria of this study were: ages 12 to 18 years, apparently in healthy condition (with no underlying diseases, including chronic kidney disease, thyroid disease, diabetes mellitus, infection and/or inflammation) as determined during the interview process. All students who participated in this study received clarifications before voluntarily signing the consent with the written permission received from their parents. This research project was approved by the human research committee of Walailak University (Reference number 030/2552).

Data Collection

Collection of socio-demographic data, such as gender, age, medical conditions, eating habits and family information, such as number of family members, educational level of parents, family income, and parents' relationship was obtained by interview method. Measuring weight and height to calculate the body mass index (BMI = weight (kg)/height $(m)^2$, referring to the BMI for age according to the Centers for Disease Control and Prevention[10] and dividing the weight into 4 groups according to the WHO (2018) criteria as follows: BMI $\geq 95^{th}$ percentile was classified as obese, BMI $\geq 85^{th}$ and $<95^{th}$ percentile as overweight, BMI $\geq 5^{th}$ and $<85^{th}$ percentile as normal and BMI $<5^{th}$ percentile as underweight.

Laboratory Examination

Blood samples were collected by 3 mL in an EDTA tube and the complete blood count (CBC) was examined by an automated cell counter, cellTEC E model (Nihon Kohden, Tokyo, Japan). Thalassemia screening was performed using the KKU-one tube osmotic fragility (KKU-OF) and KKU-dichlorophenol indophenol precipitation (KKU-DCIP) clear reagent kits (PCL Holding, Bangkok, Thailand). These screening tests are based on high effectiveness at 100% sensitivity and 69.8% specificity.[11] For the KKU-OF test, a 20 μL aliquot of EDTA blood was mixed with 2 mL of saline solution in a plastic tube with 13 mm x 75 mm cover provided by the manufacturer. The tubes were incubated at room temperature for 15 minutes. For the KKU-DCIP clear, a 20 μL aliquot of EDTA blood was mixed with 2 mL of DCIP reagent. The solution was incubated at 37°C for 15 minutes and then 20 μL of stop solution was immediately added and the solution was mixed before determining. The results of the screening tests were determined by visual inspection. The clear sample was considered as a negative result while cloudy or slightly cloudy appearance was regarded as a positive one. The diagnosis of anemia was defined according to the WHO[12] criteria. Anemia was defined as an Hb level <12 g/dL in an individual aged 12-14 years, and subjects aged 15 years and older were considered anemic with a Hb level <13 and <12 g/dL in men and women, respectively.[12]

Statistical Analysis

Data was analyzed with SPSS Version 19 (SPSS, Chicago, IL, USA). The socio-demographic data of the studied population was expressed as percentage. Continuous parameters were presented as mean and standard deviation (SD). The independent-sample t-test was performed to compare means of continuous values when the variables had 2 groups. Odds ratio (OR) and the corresponding 95% confidence interval (95% CI) were calculated to determine the association between the parameters of interest and anemia by logistic regression analysis. Statistical significance was considered when P-value $<.05$.

Results

Socio-Demographic Data of the Studied Population

A total of 200 Muslim secondary school students were enrolled, consisting of 45.0% of males and 55.0% of females, aged between 12-18 years, most in the 12-15 age group, representing 71.0%. Based on their BMI, the subjects were classified as 12.0% underweight, 76.0% normal, and 12.0% with overweight or obesity. The 73 subjects were classified as anemic, 79.5% and 20.5% of subjects with anemia were aged between 12-15 and 16-18 years, respectively. According to the eating habits related to anemia, most subjects had eating habits in the criterion of need for improvement. For family information, most subjects had 5-7 family members, most of the parents' education level was in elementary school, and the monthly household income of most participants was around 5,001-10,000 Baht according to Table 1.

Prevalence of Anemia in the Studied Population

The overall prevalence of anemia in the studied subjects was 36.5%. Of this, 79.5% and 20.5% were in the age-group of 12-15 and 16-18 years, respectively. A higher proportion of anemia was found in females (39.1%) compared to males (33.3%) counterpart. Individuals with anemia demonstrated a significantly lower mean of RBC, Hb, Hct, MCV, MCH, and MCHC than those in the non-anemic group. However, the RDW was remarkably higher in the anemic than in the non-anemic ones ($P < .05$). The consistent results were presented in Table 2.

Thalassemia Screening in the Studied Population

According to the thalassemia screening using KKU-OF and KKU-DCIP clear reagent tests, results obtained from 200 samples were divided into 4 groups:

(1). $OF^-/DCIP^-$ group, 163 (81.5%) participants had negative results on both test. Among the negative group, 126 samples belonged to the non-anemic group (99.2%), whereas only 1 sample was having anemia (0.8%), (2). $OF^+/DCIP^-$ group, 30 samples with $OF^+/DCIP^-$ results, 20 were anemic (27.4%) and 10 were non-anemic (7.9%), (3). $OF^-/DCIP^+$ group, 5 samples had $OF^-/DCIP^+$ results, 3 were anemic (4.1%) and 2 were non-anemic (1.6%) and 4). $OF^+/DCIP^+$ group, only 2 (1%) subjects had positive results on both of the tests.

Association of Anemia and Related Factors

Logistic regression analysis was performed to evaluate the association of confounding factors related to anemia, such as gender, age, BMI, thalassemia screening test, eating habits, number of family members, educational level of parents, monthly family income, and the relationship of parents. The results demonstrated that the subjects with results of $OF^+/DCIP^-$, the family number of 5 to 7 members and more than 7 people were associated with anemia with OR of 8.14 (95% CI: 3.11-21.35), 2.71 (95% CI: 1.15-6.37), and 2.83 (95% CI: 1.05-7.65), respectively (Table 3).

Discussion

This study demonstrated the association of confounding factors related to anemia, including the number of Muslim students and their family members. Family members of 5-7 persons and more than 7 people were at risk of having anemia with an odds ratio of 2.71 (95% CI: 1.15-6.37) and 2.83 (95% CI: 1.05-7.65), respectively. This result indicates that socio-economic factors affect the condition of anemia in Muslim secondary school students. In contrast, the socio-economic factor was not associated with any type of anemia in Vietnam.[13] These conflicting results may be related to the differences in ethnicity, religion, age, or gender of the studied population. The prevalence of anemia in this study was 36.5%, which is consistent with data from the nutritional survey of Thai children aged 6 months to 12 years from 2010 to 2012, that found a high prevalence of anemia in rural areas up to 41.7%.[4] On the contrary, only 8.3% of anemia was present in high-school girls aged 15 to 18 years.[8] Furthermore, a study conducted on adolescent aged 15 to 17 years in north-eastern Thailand, the prevalence of anemia was found 21.1% (8.1% in males and 13.0% in females) and 16.6% (8.9% in males and 7.7% in females) in Mukdahan and Roi-Et Province, respectively.[14] Based on the consideration of the age-group and gender, the proportion of anemia was higher in females than males. Furthermore, the prevalence of anemia tends to decrease in the older age group. These results were consistent with a previous study conducted in rural Kazakhstan.[15]

Our results also demonstrated significantly lower levels of red blood cells, Hb, Hct, MCV, MCH, and MCHC in the anemic group than in the non-anemic group, while the RDW was statistically higher than the non-anemic groups in males and females. The red blood cells morphology was represented the microcytes, ovalocytes, target cells, and hypochromia. These characteristics can be found in people with anemia from iron deficiency or people with thalassemia carrier. It was also found that anemic groups statistically significantly had more eosinophils than non-anemic groups (7.9% vs 5.1%, $P = .007$, data not shown). The detection of elevated eosinophils might indicate the infestation with parasites in this studied population as supported by an epidemiological study of strongyloidiasis at the village level in the District of Thasala, Nakhon Si Thammarat Province in 2007 and 2010 with 51.9% and 28.0% positive subjects, respectively.[16,17] As patients with strongyloidiasis had iron deficiency anemia due to the parasite that penetrates the mucosa of the small bowel causing bleeding and

Table 1. Socio-Demographic Data of the Studied Population.

	Entire	Non-anemic	Anemic	*P*-value*
General characteristics	n = 200 (%)	n = 127 (%)	n = 73 (%)	
Gender				
Male	90 (45.0)	60 (47.2)	30 (41.1)	.461
Female	110 (55.0)	67 (52.8)	43 (58.9)	
Age				
12-15 years	142 (71.0)	84 (66.1)	58 (79.5)	.053
16-18 years	58 (29.0)	43 (33.9)	15 (20.5)	
BMI				
Underweight	9 (4.5)	5 (3.9)	4 (5.5)	.443
Normal	161 (80.5)	100 (78.7)	61 (83.5)	
Overweight/obese	30 (15.0)	22 (17.3)	8 (11.0)	
Anemia				
12-15 years	58 (29.0)	N/A	N/A	N/A
16-18 years	15 (7.5)	N/A	N/A	
Eating habits				
Good eating habits	26 (13.0)	19 (15.0)	7 (9.6)	.277
Need to improve eating habits	174 (87.0)	108 (85.0)	66 (90.4)	
Family members				
1-4 persons	40 (20.0)	31 (24.6)	8 (11.0)	.065
5-7 persons	119 (59.5)	70 (55.6)	48 (65.8)	
>7 persons	41 (20.5)	25 (19.8)	17 (23.3)	
Paternal educational level				
Lower elementary education	164 (82.0)	106 (83.5)	58 (79.5)	.176
Secondary education/equivalent	32 (16.0)	20 (15.7)	12 (16.4)	
Diploma/equivalent	2 (1.0)	0 (0.0)	2 (2.7)	
Bachelor's degree	2 (1.0)	1 (0.8)	1 (1.4)	
Maternal educational level				
Lower elementary education	166 (83.0)	104 (52.0)	62 (84.9)	.298
Secondary education/equivalent	30 (15.0)	22 (17.3)	8 (11.0)	
Diploma/equivalent	2 (1.0)	0 (0.0)	2 (2.7)	
Bachelor's degree	2 (1.0)	1 (0.8)	1 (1.4)	
Family income (baht/month)				
1000-5000	50 (25.0)	36 (28.3)	14 (19.2)	.485
5001-10 000	109 (54.5)	64 (50.4)	45 (61.6)	
10 001-30 000	38 (19.0)	25 (19.7)	13 (17.8)	
30 001-60 000	2 (1.0)	1 (0.8)	1 (1.4)	
>60 000	1 (0.5)	1 (0.8)	0 (0.0)	
Relationship of parents				
Consanguineous	19 (9.5))	13 (10.2)	6 (8.2)	.640
Non-consanguineous	181 (90.5)	114 (89.8)	67 (91.8)	

N/A = not applicable.
*Chi-square test.

malabsorption.[18] Therefore, the endemic of strongyloidiasis may be related to anemia in this area.

The results of the thalassemia screening showed that the anemic group was responsible for positive only with the KKU-OF test, which can be found in subjects with iron deficiency, α-thal 1 trait, β-thal 1 trait, or HbE carriers. This anemic group was also positive only with the KKU-DCIP clear test, which can be found in Hb E trait, Hb E trait with iron deficiency, HbH, or other unstable hemoglobins. Moreover, the anemic group was positive with both tests and can be found in people with Hb E trait or homozygous Hb E. In univariate logistic regression revealed that results of OF^+/$DCIP^-$ were associated with anemia condition. After adjusting the number of family members, having OF^+/$DCIP^-$ results demonstrated as an independent related factor for anemia in this study (Adjusted OR = 7.69, 95% CI: 2.90-20.26, $P < .001$). The non-anemic group also tested positive for thalassemia screening tests in the lowest rates. These

Table 2. Comparison of Red Blood Cell Indices of Non-Anemic and Anemic Subjects.

	Male (n = 90)			Female (n = 110)		
Parameters	Non-anemic (n = 60)	Anemic (n = 30)	*P*-value*	Non-anemic (n = 67)	Anemic (n = 43)	*P*-value*
RBC ($\times 10^6/\mu L$)	5.01 ± 0.42	4.76 ± 0.59	.003	4.61 ± 0.28	4.35 ± 0.43	<.001
Hb (g/dL)	13.45 ± 0.67	11.59 ± 1.18	<.001	12.79 ± 0.61	11.06 ± 0.89	<.001
Hct (%)	40.40 ± 1.81	35.58 ± 2.85	<.001	38.62 ± 1.68	34.12 ± 2.28	<.001
MCV (fL)	81.02 ± 5.42	75.47 ± 8.28	.001	83.99 ± 4.49	78.97 ± 7.85	.001
MCH (pg)	26.99 ± 2.15	24.61 ± 3.37	.001	27.82 ± 1.70	25.64 ± 3.05	<.001
MCHC (g/dL)	33.29 ± 0.66	32.51 ± 1.21	.001	33.10 ± 0.57	32.39 ± 0.85	<.001
RDW (%)	13.46 ± 0.39	14.03 ± 1.03	.002	13.45 ± 0.50	14.15 ± 0.84	<.001

Data was presented as mean ± SD.
*Independent-sample *t*-test.

Table 3. Association of Related/Confounding Factors and Anemia.

General characteristics	Odds ratio (95% CI)	*P*-value*
Gender		
Female	1.28 (0.72-2.30)	.400
Male	1	
Age		
12-15 years	1.84 (0.94-3.63)	.075
16-18 years	1	
BMI		
Underweight	0.39 (0.14-1.11)	.070
Overweight/obese	0.61 (0.24-1.57)	.305
Normal	1	
Thalassemia screening tests		
$OF^+/DCIP^-$	8.14 (3.11-21.35)	<.001
$OF^-/DCIP^+$	3.62 (0.65-20.29)	.143
$OF^+/DCIP^+$	1.75 (0.11-28.40)	.694
$OF^-/DCIP^-$	1	
Eating habits		
Need to improve eating habits	1.34 (0.55-3.26)	.874
Good eating habits	1	
Family members		
5-7 persons	2.70 (1.15-6.37)	.020
7 persons	2.83 (1.05-7.65)	.037
≤4 persons	1	
Paternal educational level		
Lower elementary education	0.81 (0.39-1.68)	.572
Upper secondary education	1	
Maternal educational level		
Lower elementary school	1.18 (0.54-2.60)	.679
Upper secondary school	1	
Family income (baht/month)		
≤10 000	1.09 (0.53-2.24)	.826
≥10 001	1	
Relationship of parents		
Consanguineous	0.72 (0.27-1.97)	.524
Non-consanguineous	1	

*Logistic regression analysis.

positive results may be due to non-clinically significant thalassemia and hemoglobinopathy, as well as a mild form of iron deficiency. The limitation of our study was that thalassemia was not confirmed and that the iron status was also not determined. However, the previous study reported thalassemia or abnormal hemoglobin in the Province of Nakhon Si Thammarat at the rate of 12.9%.[19] Therefore, the Hb typing or the molecular study of thalassemia and the iron profile should be further investigated to verify specific types of thalassemia occurred in this region.

Conclusions

Based in the result obtained, the prevalence of anemia in our studied area is 36.5%. The present study demonstrated the association of anemia with confounding/related factors including the positive results of the KKU-OF test, a family number of 5 to 7 and more than 7 members with anemia condition. These findings suggest that thalassemia and socioeconomic factors may contribute to anemia in Muslim secondary school students. A more comprehensive study with larger sample size is highly recommended to further provide additional information for public health strategies of controlling anemia in Muslim students in the region.

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