

Physical-maturation with health education on the incidence of anemia among adolescents who married at a young age

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ABSTRACT

Physical maturity and the incidence of anemia in adolescents who marry at a young age have an impact on the biological and physiological unpreparedness of the adolescent body that is not yet fully mature against the increased risk of anemia, especially in early pregnancy. The solution in this paper provides health education and increased awareness of the dangers of early marriage to physical health, especially the risk of anemia. Nutrition intervention programs and iron supplements for adolescent girls. The purpose of this study was to evaluate the effect of physical maturity on the incidence of anemia in adolescents who marry at a young age. Quantitative research method with quasi-experimental pre-post test design with control group. The population of the study was 54 young women who were married at a young age. The sample size of 44 respondents. Sampling was done using the accidental technique. Data were analyzed using the Chi-square test. The difference in mean hemoglobin levels in adolescents before and after the intervention was analyzed using the paired t-test. Based on the results of statistical test, a p-value of 0.000 was obtained ($p\text{-value} \leq 0.05$), which indicated that the difference was statistically significant.

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1. INTRODUCTION

Anemia among adolescents who marry at a young age is a serious public health issue, especially in developing countries, including Indonesia. Anemia can disrupt the quality of life as well as physical and mental development in adolescents, which ultimately has an impact on the health of women and children. One of the factors that plays an important role in the incidence of anemia is physical maturation [1]. In adolescents who marry at a young age, the physical maturity process is not optimal, which can lead to the risk of anemia. Anemia is a significant health problem, which is characterized by a lower number of red blood cells or hemoglobin level than normal, which can disrupt the body's ability to carry oxygen to body tissues [1]. Anemia in adolescents who marry at a young age needs serious attention for several reasons that can affect their health. Proper medical management for anemia can prevent complications that may endanger the health of the child to be born [2]. Anemia is associated with poor cognitive development in children and work capacity in adults, thus affecting the country's economic development [3]. In pregnant women, iron deficiency anemia is also associated with adverse reproductive outcomes such as premature birth, low birth weight babies, and reduced iron stores in babies, which may cause abortion, birth defects or growth and development for the fetus or baby [4].

At the global level, anemia in adolescents and women of childbearing age remains a serious concern because it is closely related to the quality of human resources and maternal health. WHO data for 2021 showed the prevalence of anemia in women aged 15-49 years at 29.9% and the prevalence of anemia in children at 60.2% [5].

In Indonesia, anemia remains a significant health problem. According to data from the Indonesian Ministry of Health, conducted through the Indonesian Health Survey and Basic Health Research, the prevalence of anemia among adolescent girls has increased in recent years. Based on data derived from the Indonesian Health Survey (2023), the prevalence of anemia for all age groups in Indonesia was 16.2%; and it was relatively higher for the female group by 18% compared to 14.4% for the male group [6]. According to a preliminary survey conducted in Bangkalan district, there were 54 adolescents who married at a young age, 44 of whom had anemia, including mild, moderate, and severe anemia [7]. They revealed that anemia interfered with daily activities, wherein they were often tired and had dizzy eyes. One of the respondents was an adolescent with anemia who had a baby with stunting [8]. The national burden of anemia not only impacts individual health but also has consequences for the quality of future generations. Teenagers with anemia are at higher risk of high-risk pregnancies.

Failure to manage anemia can result in impaired health and quality of life among millions of women, and it can disrupt children's development and learning in the future [9]. At a young age, adolescents' bodies are still in the growth and development phase, both physically and mentally. At the same time, adolescents have to face the physical and psychological burdens of new roles in marriage and pregnancy [10]. Hormonal changes that occur during puberty and imbalances in nutritional needs often affect nutritional status, including iron levels, which are important for preventing anemia. E-modules or electronic modules as a means of health education have great potential to increase adolescents' knowledge about nutrition, reproductive health, and the prevention of anemia [11]. The use of e-modules regarding health education can provide information that is easy to access and interactive, so that adolescents may better understand how to maintain their health, especially in the context of getting married at a young age. This is in line with a previous study on children's attitudes regarding the safety of snacks. It was revealed that the mean score before health education was 62.18, and after health education it increased to 80.70. The t-test obtained a p-value of $0.000 < \alpha 0.05$ [12]. Such a finding indicated that there was a significant difference in children's attitudes regarding the safety of snacks before and after health education.

The failure of current interventions, such as iron supplementation and reproductive health counseling, is primarily due to the lack of integration of these approaches with adolescents' physical and biological maturation [13]. Most programs focus solely on providing iron supplements or providing general information about anemia, without considering that adolescents who marry at an early age are still in a stage of reproductive organ development and physiological development that is not yet optimal. This condition increases iron requirements due to menstruation, body growth, and the possibility of early pregnancy. When supplementation is provided without a good understanding of these biological changes, compliance with iron tablet consumption tends to be low, and the intervention's benefits are not maximized [1].

The solutions proposed in this paper include Health education to prepare adolescents for physical maturity in the form of education and awareness raising on the dangers of early marriage on physical health, especially the risk of anemia. Nutrition intervention programs and iron supplements for adolescent girls. Physical maturation is an important aspect that needs to be considered in maintaining adolescent reproductive health, especially for those who marry at a young age [14]. Adolescents who have not reached optimal physical maturity are at risk of experiencing various complications of pregnancy and childbirth, such as anemia, premature birth, and the risk of maternal and infant death. Therefore, ensuring that adolescents achieve sufficient physical maturity before marriage and pregnancy is very important to support optimal reproductive health and a healthier future [15].

Lack of health education for adolescents causes them to be unaware of certain symptoms such as fatigue and dizziness, as well as the symptoms of anemia. Therefore, adolescents are not aware of the need to seek treatment or pay attention to healthier eating patterns [16]. Adolescents face a certain process which includes significant physical and hormonal changes, which may affect nutritional needs, including iron, which is very important for preventing anemia [17]. The physical maturation e-module involves education on nutritional balance, routine health checks for regular hemoglobin and blood checks, Fe and Vitamin B12 tablets, rest and sleep coverage, exercise, iron supplements, reproductive health education, and stress management [18].

This paper also clearly explains the observations of previous studies that have been conducted on similar topics. A number of previous studies have shown that marriage and pregnancy at a young age are closely related to the high risk of anemia, as a result of not achieving a biologically mature physical condition, including nutritional status and reproductive development systems [19]. However, there is still limited research that specifically examines physical maturity variables with the incidence of anemia in groups

of young married adolescents, so this study is expected to fill this gap and provide a deeper scientific contribution [20].

This study offers a new approach by combining physical maturity factors with the incidence of anemia in adolescents who marry young. Things that are novel about this study Integrative approach between physical maturity and early marriage. This study does not only look at aspects of pregnancy or nutrition, but examines how the level of biological maturity (e.g., age of menarche, body development) affects susceptibility to anemia in the context of early marriage. Previous studies generally discuss anemia in adolescents in general. This study targets a more specific subgroup, namely adolescents who have been married, who face double risks due to suboptimal maturity and the biological demands of marriage/pregnancy. With a new understanding of the relationship between physical maturity and anemia in the context of early marriage, the results of this study can provide a scientific basis for adolescent health interventions and early marriage policies.

Early marriage or teenage marriage often puts adolescents at higher health risks, including anemia which can exacerbate their physical and mental conditions. Therefore, educational intervention through e-module based on an understanding of physical maturation is very important to decrease the incidence of anemia among adolescents who marry at a young age. Physical maturation or the physical readiness of adolescents plays an important role in preventing anemia. Based on the background above, the researchers are interested in conducting a study entitled "Physical maturation using e-module on the incidence of anemia among adolescents who married at a young age." This is considered as a solution to avoid adverse impacts and improve the health of women and children due to early marriage or teenage marriage by preparing for a quality pregnancy. This research also makes a significant contribution to the development of health policies and the achievement of the Sustainable Development Goals (SDGs). Efforts to prevent anemia in young married adolescents support SDG 3 (good health and well-being), specifically in reducing anemia rates, improving maternal health, and preventing pregnancy complications at a young age. Furthermore, this research supports SDG 4 (quality education) by strengthening reproductive health and nutrition education for adolescents, and SDG 5 (gender equality) by promoting women's health protection and preventing the negative impacts of early marriage.

2. METHOD

This was a quantitative study using a quasi-experimental design and pre-post test design with a control group. This study involved two groups of subjects [21]. Pre-test for the intervention group was conducted by checking Hb levels, which was followed by treatment in the form of providing physical-maturation health education using e-module with a technology-based approach. It is expected that adolescents would be more understanding about the importance of diet or nutrition, Fe tablets, the prevention of anemia and the importance of health monitoring during preparation for pregnancy and during pregnancy [22]. Education and assistance were provided for one month, and then a post-test was performed by checking Hb levels. Respondents in the control group were only given counseling on Fe tablets.

The population involved all adolescents who married at a young age in Bangkalan District, Madura in September-November 2024 as many as 54 people. The sample size was determined using the Slovin formula, and the calculation resulted in 44 respondents. The study samples were selected through accidental sampling technique. 44 respondents were assigned into two groups, namely the intervention group and the control group, which consisted of 22 respondents, respectively.

The study variables consisted of the independent variable of physical maturation and the dependent variable of anemia. The data collection instrument used here was the physical maturation questionnaire. Furthermore, anemia was assessed through Hemoglobin levels. The research instrument used in the study, "Physical maturation with health education on the incidence of anemia among adolescents who married at a young age," consisted of a questionnaire covering respondent characteristics, reproductive health knowledge, physical maturation, anemia prevention behavior, and health education. Before being used in the main study, the questionnaire underwent validity and reliability testing to ensure that it measured variables accurately and consistently.

Data were analyzed using univariate and bivariate analysis through the IBM SPSS software. Univariate analysis was applied to determine frequency distribution, while bivariate analysis applied the Chi-square test. Differences in the mean hemoglobin levels in female adolescents before and after intervention was analyzed using the paired t-test (normal data distribution) between groups [23].

3. RESULTS AND DISCUSSION

Table 1 shows the demographic and biological characteristics of the adolescent respondents in this study. The majority of respondents were in the age range of 17–18 years (50%), with a relatively even

distribution between the control and intervention groups [24]. Most respondents had a final education level of junior high school/equivalent (47.7%), indicating that most adolescents in this study had not completed high school education when they married [25]. In terms of age of marriage, more than half of the respondents married at the age of 15–17 years (56.8%), which is considered an early marriage age. Only 27.3% married at the age of ≥ 18 years, in accordance with the age limit for marriage recommended by law in Indonesia [26]. Anemia status showed a striking difference between groups. In the control group, the proportion of adolescents with anemia reached 59.1%, while in the intervention group it was only 31.8%. This could indicate the influence of the intervention on the incidence of anemia. This finding is in line with the hypothesis that interventions related to physical maturation and early marriage education can contribute to reducing the risk of anemia. Regarding physical maturation signs, most respondents experienced menarche at age ≥ 12 years (70.5%). However, around 29.5% had experienced menarche before age 12, which could be an indicator of early maturation and potentially related to increased risk of early marriage and reproductive health problems such as anemia [15]. All baseline characteristic variables showed p-values > 0.05 , which means that both groups (control and intervention) were homogeneous in terms of age, education level, age of marriage, anemia status, and signs of physical maturation.

Table 1. Characteristics of research respondents (n = 44)

	Characteristics	Control group (n = 22)	Intervention group (n = 22)	Total (n = 44)	p-value
Age	15–16 years	6 (27.3%)	4 (18.2%)	10 (22.7%)	0.85
	17–18 years	10 (45.4%)	12 (54.5%)	22 (50%)	
	19–20 years	6 (27.3%)	6 (27.3%)	12 (27.3%)	
Last education level	No school	2 (9.1%)	1 (4.5%)	3 (6.8%)	0.76
	Elementary school/equivalent	5 (22.7%)	3 (13.6%)	8 (18.2%)	
	Junior high school/equivalent	10 (45.4%)	11 (50%)	21 (47.7%)	
	High school/equivalent	5 (22.7%)	7 (31.8%)	12 (27.3%)	
Age at marriage	< 15 years	4 (18.2%)	3 (13.6%)	7 (15.9%)	0.91
	15–17 years	12 (54.5%)	13 (59.1%)	25 (56.8%)	
	≥ 18 years	6 (27.3%)	6 (27.3%)	12 (27.3%)	
Anemic status	Anemic	13 (59.1%)	7 (31.8%)	20 (45.5%)	0.77
	Not anemic	9 (40.9%)	15 (68.2%)	24 (54.5%)	
Signs of physical maturation	Menarche < 12 years	8 (36.4%)	5 (22.7%)	13 (29.5%)	0.79
	Menarche ≥ 12 years	14 (63.6%)	17 (77.3%)	31 (70.5%)	

Source: Primary Data 2024

3.1. Results of the independent t-test between physical maturation and anemia in adolescents who married at a young age

Based on the results of the independent t-test in Table 2, it was found that all physical maturation indicators had a significant relationship to anemia status in adolescents who married at a young age. The average hemoglobin (Hb) level in the intervention group was higher (11.4 g/dL) compared to the control group (10.5 g/dL), with a p-value of 0.008, indicating a significant difference. Variables such as reproductive organ development, body growth, age of menarche, puberty status, and nutritional status showed a p-value < 0.05 , indicating that there was a significant difference between the two groups. The intervention group that had better physical maturity status also tended to have higher Hb levels, so they experienced less anemia. These results indicate that physical maturity plays an important role in the incidence of anemia, especially in adolescent girls who married young [24]. Body conditions that are not yet optimally mature can increase the risk of health problems including anemia, because the increased need for iron is not balanced by sufficient body reserves [15].

Table 2. Results of the independent t-test between physical maturation and anemia in adolescents who married at a young age (n = 44)

Physical maturation variable	Control group (Mean $\pm$ SD)	Intervention group (Mean $\pm$ SD)	p-value	Information
Reproductive organ development (observation score)	3.1 $\pm$ 0.7	3.6 $\pm$ 0.5	0.012*	Significant
Body growth (height/weight Z-score index)	-0.8 $\pm$ 1.1	-0.2 $\pm$ 0.9	0.045*	Significant
Age of menarche (years)	11.8 $\pm$ 0.9	12.3 $\pm$ 0.8	0.041*	Significant
Pubertal status (Tanner scale)	2.9 $\pm$ 0.6	3.4 $\pm$ 0.7	0.019*	Significant
Nutritional status (BMI/A or BMI)	17.1 $\pm$ 1.5	18.4 $\pm$ 1.3	0.022*	Significant
Hb levels (anemia indicator, g/dL)	10.5 $\pm$ 0.9	11.4 $\pm$ 1.0	0.008*	Significant

*Independent t-test, $\alpha = 0.05$

*Significant if p < 0.05

3.2. Difference in the mean hemoglobin levels between the pre-test and post-test in both groups

Based on Table 3, it was revealed that the mean initial haemoglobin levels in the intervention group and the control group were 10.23 gr/dl and 10.48 gr/dl, respectively. After the intervention of physical-maturation health education using e-module, the mean haemoglobin level in the intervention group increased by 2.07 gr/dl to 12.30 gr/dl. On the other hand, the mean haemoglobin level in the control group increased by 0.62 gr/dl to 11.10 gr/dl. In addition, the results of the paired t-test obtained a p-value of $0.000 \leq \alpha 0.05$ for both groups, which indicated that there was a significant difference in the mean hemoglobin levels between pre-test and post-test.

Table 3. Difference in the mean hemoglobin levels between the pre-test and post-test in both groups

Variable	Group		p-value
	Intervention (n = 22)	Control (n = 22)	
Hemoglobin			
Pre -test	10.23 (0.734)	10.48 (1.085)	0.387*
Post- test	12.30 (0.734)	11.10 (1.091)	0.000*
Intervention			
P value	0.000**	0.000**	

Source: *Independent t-test, **t paired

Increased hemoglobin levels are greatly influenced by iron intake, individual knowledge about the importance of nutrition, and behavioral changes related to diet and reproductive health. Effective health education can increase adolescent knowledge and awareness of the importance of iron, so that it can encourage behavioral changes, such as consuming foods high in iron, improving diet, and avoiding risk factors for anemia such as excessive tea/coffee consumption or lack of animal protein intake (Ministry of Health of the Republic of Indonesia, 2016; WHO, 2021).

Education through e-module can be one of the effective methods in delivering information because it combines visual, text, and interactive elements that can attract the attention of teenagers. The Health Belief Model (HBM) theory states that changes in health behavior occur when someone feels vulnerable to a disease and understands the benefits of preventive measures taken. In this context, teenagers who receive education about the importance of physical maturity and its relationship to anemia are likely to be more motivated to improve their diet [27].

These results are in line with research conducted by Lestari *et al.* [28], which showed that providing digital media-based nutrition education increased the knowledge and compliance of adolescent girls in consuming foods high in iron, which had a positive impact on increasing hemoglobin levels [29]. In addition, research by Sari *et al.* [30] also found that the use of technology-based educational media can increase the effectiveness of anemia prevention programs among students.

Thus, it can be concluded that health education interventions using e-module are an effective strategy in increasing hemoglobin levels in adolescents. This intervention not only increases knowledge but also encourages positive behavioral changes in terms of nutritional intake and healthy lifestyles [29].

Health education through e-modules provides convenience for respondents in receiving health information in a more flexible and interactive manner. This approach is in line with the planned health behavior theory, which explains that an individual's intention to behave healthily is influenced by three main constructs, namely attitudes toward behavior, subjective norms, and perceived behavioral control [31]. In the context of e-modules, information presented clearly and attractively can shape positive attitudes toward healthy behavior. In addition, interactive features and relevant content can strengthen subjective norms by displaying social support or behavioral examples from the surrounding environment. Ease of access and use of e-modules also increases the perception of control over behavior, because individuals feel more able to understand and apply health information in their daily lives. Thus, e-modules become an effective means of shaping healthy intentions and behaviors in accordance with the Planned Health Behavior theoretical framework [32].

3.3. Difference in the increase in hemoglobin levels between the two groups

The results presented in Table 4 revealed that the statistical test through the independent t-test obtained a p-value of 0.000 ($p\text{-value} < \alpha = 0.05$). It was found that there was a difference in the increase in the mean hemoglobin levels in both groups by 1.45 gr/dl. Thus, it can be concluded that there was an effect of physical maturation using e-module on the incidence of anemia among adolescents who married at a young age.

Table 4. Difference in the increase in hemoglobin levels before and after intervention

Variable	Intervention (n = 22)	Control (n = 22)	p-value
Mean hemoglobin levels	2.07 (0.38)	0.62 (0.82)	0.000*
Mean difference	1.45		

*Independent t-test

Based on the results of statistical tests using an independent t-test, a p-value of 0.000 ($\leq \alpha$ 0.05) was obtained, indicating that there was a significant difference between the intervention group and the control group in increasing hemoglobin levels. The average difference in increasing hemoglobin levels was 1.45 gr/dl in the group that received intervention through e-modules on physical maturation. These results indicate that the use of e-modules in education on physical maturation has an effect on reducing the incidence of anemia in adolescents who marry at a young age.

Furthermore, health education serves as a cue to action that motivates adolescents to change their health behaviors. Adolescents who previously considered anemia a common condition begin to understand its impact on maternal and fetal health, such as chronic fatigue, pregnancy complications, preterm birth, and stunting in children. Thus, health education interventions have a more sustainable effect than supplementation alone, as they can shape health awareness, attitudes, and behaviors internally [14].

The results of this study indicate that physical maturation interventions with health education contribute to a reduction in the incidence of anemia in adolescents who marry at a young age. These findings indicate that health education not only increases knowledge but also influences changes in adolescents' health behaviors by raising awareness of the importance of biological readiness and nutritional status before pregnancy. In adolescents who marry early, immaturity of reproductive organs and high iron requirements during growth increase the risk of anemia, especially when combined with inadequate dietary patterns and limited access to reproductive health information [8].

Theoretically, adolescence is an important transition period marked by physical growth and increased nutritional needs, especially iron, which is very important in the formation of hemoglobin. When adolescent girls marry and become pregnant at a young age, the need for iron becomes higher, and if not balanced with adequate education and understanding, the risk of anemia increases [33].

Providing education through e-modules allows adolescents to obtain information about the importance of nutritional intake, hemoglobin function, and the impact of anemia, in an interactive and easily accessible way. This is in line with the HBM theory, which states that increased knowledge and risk perception can encourage individuals to change their health behavior. E-modules designed with this approach are able to increase adolescent awareness of the importance of physical maturation before marriage or pregnancy, as well as increase the behavior of consuming nutritious foods and iron supplementation [27].

This study is supported by findings from previous studies, such as a study by Nuraini and Andriani [34], which showed that digital-based educational interventions can improve adolescents' knowledge and attitudes in preventing anemia. Another study by Styaningrum *et al.* [35] also found that adolescents who received intensive nutrition education experienced a significant increase in hemoglobin levels compared to the group that did not receive education [29]. The findings of this study also show that iron supplementation without strengthening education and biological readiness is often ineffective. This may occur because adolescents do not yet understand the importance of adherence to iron supplementation, lack awareness of the risks of anemia, and are still influenced by cultural and social factors related to early marriage. Therefore, integrating reproductive health education, physical development, and nutritional interventions is a more comprehensive approach to preventing anemia in young married adolescents.

Thus, the results of this study support the use of learning technology such as e-modules as an effective approach in anemia prevention programs, especially for groups of young married female adolescents. This effort also supports the achievement of SDGs, especially in terms of improving adolescent health and reducing anemia rates.

4. CONCLUSION

It can be concluded that there was an effect of physical maturation using e-module on the incidence of anemia among adolescents who married at a young age. E-module is recommended as a learning medium to increase the understanding of adolescents who marry at a young age regarding the importance of nutrition and body health during their physical transition period. The use of e-module in health education was proven to effective in increasing knowledge on adverse effects and prevention of anemia.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : Conceptualization	I : Investigation	Vi : Visualization
M : Methodology	R : Resources	Su : Supervision
So : Software	D : Data Curation	P : Project administration
Va : Validation	O : Writing - Original Draft	Fu : Funding acquisition
Fo : Formal analysis	E : Writing - Review & Editing	

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

The current study was ethically assessed by the Ethics Commission of the Faculty of Health Sciences, PGRI Adi Buana University, Surabaya, as stated in the ethical approval number 148-KEPK, Faculty of Health Sciences, PGRI Adi Buana University, Surabaya, September 14, 2024.

DATA AVAILABILITY

The data supporting the findings of this study are available and may be obtained by contacting the corresponding author.

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