CHRONIC ENERGY DEFICIENCY (CED) PREDICTION MODEL IN ADOLESCENT FEMALES (10-19 YEARS) IN INDONESIA

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ABSTRACT
Chronic Energy Deficiency (CED) in Indonesia has not yet reached an acceptable threshold. CED among adolescent girls can be caused by both direct and indirect factors. This research was conducted to develop a predictive model for the incidence of CED among adolescent girls (aged 10–19 years) in Indonesia. This study is a secondary research using a cross-sectional design. The data were obtained from the 2023 SKI dataset, with a sample of 55,506 adolescent girls aged 10–19 years. The data analysis was conducted using Complex Samples Chi-Square and Cox Regression predictive modeling. The study found that the proportion of CED among adolescent girls in Indonesia was 46.2%. The most dominant factor influencing CED among adolescent girls is age (PR = 1.430; 95% CI: 1.367–1.495), indicating that girls aged 10–14 years were at a higher risk of experiencing CED compared to those aged 15–19 years. Therefore, it is recommended that adolescent girls, especially those aged 10–14 years, maintain healthy behaviors, do a physical activity, and eat a lot of fruit and vegetable.
Keywords: CED, Age, Adolescent Girls, SKI 2023

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INTRODUCTION

Chronic Energy Deficiency (CED) is a condition of malnutrition in which an individual experiences a prolonged deficiency in food intake, potentially leading to other health problems or disorders. CED is one of the conditions that can result from an imbalance in the intake of protein, energy, or other essential nutrients required by the body (1). CED can be measured by assessing a person's Mid-Upper Arm Circumference (MUAC). Adolescent girls are classified as having CED if their MUAC is <23,5 cm for those aged over 12 years and <21 cm for those aged 10–12 years (2).

Adequate nutritional intake is essential for maintaining health and preventing various diseases. A balanced diet provides energy, vitamins, minerals, and other vital substances. Despite a decline in malnutrition rates in recent years, Indonesia still faces nutritional problems such as micronutrient deficiencies (e.g., anemia), overnutrition (obesity), and chronic energy deficiency (CED). Prolonged CED can cause serious health issues such as stunting, anemia, osteoporosis, and even death (3). Previous studies have shown that maternal CED before pregnancy is one of the causes of stunting in children (4).

Adolescent girls are a vulnerable group for CED due to their growth period, which demands higher energy and nutritional intake. CED can hinder physical growth and organ development, as well as decrease productivity in adolescents (5). In Indonesia, the prevalence of CED among adolescents remains high. According to the 2018 Basic Health Research (Riskesdas), the prevalence of CED was recorded at 14.5%, which increased by 6.1% in the 2023 Indonesian Health Survey (SKI), reaching 20.6% (6,7). Furthermore, 40% of deaths in developing countries are associated with CED. Globally, the prevalence of CED in 2021 was

reported at 22.3% in Uganda, 19.5% in India and Botswana, 8.5% in Malaysia, and 2.8% in Colombia (8).

CED can be caused by both direct and indirect factors. Direct factors include insufficient energy intake, illnesses, and age of menarche. Indirect factors, such as socioeconomic status, education, and access to healthcare services, also contribute to the incidence of CED (9). This study is not the first study using a predictive model. In previous years, there were studies that used this model using data from Riskesdas 2013 and Riskesdas 2018 related to the incidence of CED. There is a differences between this research and those study. Those research were focusing in women of childbearing age, meanwhile this study focusing in adolescent girls. Based on the above description, the authors are interested in conducting this study to develop a predictive model of CED among adolescent girls aged 10–19 years in Indonesia. As it is known that the number of CED incidents has increased, so a predictive model study is needed in order to help prevent an increase of CED in the future

METHODS

This research is a type of secondary research, which uses data obtained from external sources. The data used in this study were sourced from the Survei Kesehatan Indonesia (SKI) 2023. The study design applied was cross-sectional. The study was conducted across all regions in Indonesia, representing districts/cities comprehensively. The sample consisted of adolescent girls aged 10–19 years in Indonesia, total sampel in this study is 55,506 sampel. The sampling technique used was Probability Proportional to Size (PPS) with linear systematic sampling and a two-stage sampling approach. Data processing in this study involved several steps, including editing, data selection, coding and scoring, cleaning, and weighting.

The dependent variable in this study was CED, defined as a Mid-Upper Arm Circumference (MUAC) of <23.5 cm for those aged >12 years and <21 cm for those aged 10–12 years. Non-CED was defined as MUAC ≥23.5 cm for those aged >12 years and 21–23.7 cm for those aged 10–12 years. The independent variables included Age (10–14 years and 15–19 years), education level (low and high), employment status (employed and unemployed), marital status (never married, ever married, currently married), residence (rural and urban), household size (<5 members and ≥5 members), infectious diseases (yes or no), non-communicable diseases (yes or no), age at menarche (late, normal, early), physical activity (high, moderate, low), fruit and vegetable consumption (poor and good), personal hygiene (poor and good), environmental sanitation (poor and good), socioeconomic status (lowest, lower-middle, middle, upper-middle, highest), and access to health care fasilities (difficult and easy).

Data were processed using a statistical data analysis software and Microsoft Excel. The analysis included are univariate analysis to determine frequency distributions, bivariate analysis using the chi-square test, and multivariate analysis using Cox regression modeling. In the chi-square test, a variable is considered significantly associated if the p-value is <0.005. In the Cox regression, variables are considered model candidates if their bivariate test result has a significance value of <0.25. After the initial model test, any variable with a p-value >0.05 is removed from the model, starting with the highest p-value. The Cox regression test is repeated until all variables have p-values ≤0.05. The change in Prevalence Ratio (PR) values (Adjusted

PR vs. Crude PR) is then calculated. If the difference in PR is greater than 10%, the previously excluded variable is considered a confounder, and the model must be re-tested.

Prior to conducting this research, the authors obtained written permission from the Public Health Study Program, Faculty of Medicine and Health Sciences, Jambi University. Additionally, permission was requested to access the secondary data of the 2023 Indonesian Health Survey (SKI), along with ethical clearance approval from the Health Research Ethics Commission of the Health Development Policy Agency (BKPK), Ministry of Health of the Republic of Indonesia.

RESULTS

The subjects of this study were adolescent girls aged 10–19 years, with an average age of 14.25 years. The average Mid-Upper Arm Circumference (MUAC) among adolescent girls was 23.16 cm, ranging from 10 to 59 cm. The average household size was 4.31 people, with a range of 1 to 15 individuals. The average physical activity level, measured in METs (minutes/week), was 2,757.14, with a range from 0 to 68,040 minutes/week (Table 1).

Table 1. Respondent Characteristics

Variable	Mean	Median	(95% CI)	SD	Min-Max
MUAC Size (cm)	23,16	23,00	23,13-23,19	3,683	10-59
Age (year)	14,25	14,00	14,22-14,27	2,830	10-19
Number of Families (person)	4,31	4,00	4,30-4,32	1,245	1-15
Physical Activity METs (minute/week)	2757,1432	924,00	2721,10-2793,18	4332,099	0-68040

Source: Processed Secondary Data, 2023

The proportion of adolescent girls with CED in Indonesia in 2023 was 46.2%. By age group, the proportion was 53.4% among girls aged 10–14 years and 46.6% among those aged 15–19 years. The majority (89.7%) of adolescent girls had a low education level, and 95.9% were not employed. A total of 98.3% had never been married. Regarding residence, 38.3% lived in rural areas. About 37.5% lived in households with five or more members. The proportion of those with infectious diseases was 5.6%, while non-communicable diseases affected 1.7%.

Regarding menarche, 19.9% of adolescent girls experienced late menarche, while 57.4% had normal and 22.7% had early menarche. About 40.4% engaged in high-intensity physical activity, while 41.4% did low-intensity activity. A total of 98.7% had poor fruit and vegetable consumption habits, and 53% had poor personal hygiene. In terms of environmental sanitation, 42.1% were classified as poor. Socioeconomic status was distributed as follows: 14.1% in the lowest quintile, 21.6% lower-middle, 19.5% middle, 23.3% upper-middle, and 21.5% in the highest group. Furthermore, 10.2% of adolescent girls had limited access to health services (Table 2).

Table 2. Distribution of Determinant Variables of Chronic Energy Deficiency among Adolescent Girls (10–19 Years) in Indonesia (n = 55,506)

Variable	Frequency (n)	Percentage (%)	95% *Confidence Interval*	
			Lower	*Upper*
Chronic Energy Deficiency				
CED	25643	46,2	45,4	47,0
Not CED	29862	53,8	53,0	54,6
Age				
10-14 Years	29650	53,4	52,7	54,1
15-19 Years	25855	46,6	45,9	47,3
Education				
Low	49779	89,7	89,2	90,1
High	5726	10,3	9,9	10,8
Occupation				
Not Working	53212	95,9	95,6	96,1
Working	2293	4,1	3,9	4,4
Marital Status				
Single	54568	98,3	98,1	98,5
Married	76	0,1	0,1	0,2
Was Married	861	1,6	1,4	1,7
Residence				
Rural	21256	38,3	37,7	38,9
Urban	34249	61,7	61,1	62,3
Number of Families				
Big	20793	37,5	36,7	38,2
Normal	34712	62,5	61,8	63,3
Infectious Disease				
Yes	3092	5,6	5,2	5,9
No	52413	94,4	94,1	94,8
Non-Infectious Disease				
Yes	926	1,7	1,5	1,9
No	54579	98,3	98,1	98,5
Age of Menarche (n=14333)				
Slow	2855	19,9	19,3	20,6
Normal	8230	57,4	56,6	58,3
Fast	3246	22,7	21,9	23,4
Physical Acticity				
Heavy	22443	40,4	39,6	41,3
Moderate	10092	18,2	17,6	18,8
Light	22970	41,4	40,6	42,2
Fruit and Vegetables Consumption				
Not Good	54800	98,7	98,6	98,9
Good	705	1,3	1,1	1,4
Personal Hygiene				
Not Good	29401	53,0	52,1	53,8
Good	26104	47,0	46,2	47,9
Environmental Sanitation				
Not Good	23372	42,1	41,3	43,0
Goood	32133	57,9	57,0	58,7
Social Economic				
Bottom	7811	14,1	13,6	14,6
Lower Middle	12002	21,6	21,0	22,3
Middle	10804	19,5	18,9	20,1
Higher Middle	12948	23,3	22,7	24,0
Highest	11938	21,5	20,8	22,2
Access to Health Facilities				
Difficult	5636	10.2	9,7	10,7

Variable	Frequency (n)	Percentage (%)	95% *Confidence Interval*	
			Lower	*Upper*
Easy	49869	89,8	90,3	90,3

Source: Processed Secondary Data, 2023

The bivariate analysis results showed that adolescent girls aged 10–14 years were 1.8 times more likely to experience CED compared to those aged 15–19 years (OR = 1.821). Similarly, those with low education had a 1.9 times higher risk (OR = 1.975), and those not working had a 1.97 times higher risk (OR = 1.969). Girls who had never married were at 1.8 times higher risk than married peers. However, girls who had ever been married were found to be protective against CED compared to currently married girls, although this was not statistically significant.

Girls living in rural areas were 1.2 times more likely to suffer from CED than urban residents. Larger household size also showed a significant association with CED (OR = 1.1). Interestingly, girls with infectious diseases had a protective effect, though not statistically significant. Meanwhile, those with non-infectious diseases had a slightly increased risk (OR ≈ 1.0), also not statistically significant.

Girls with late or normal menarche had 1.4 times higher risk of CED compared to those with early menarche. Heavy physical activity was protective, while moderate activity showed no significant effect. Girls with poor fruit and vegetable consumption had a 1.5 times higher risk (OR = 1.486). Poor personal hygiene and environmental sanitation were associated with higher CED risk, but not significantly related. In terms of socioeconomic status, girls from the lowest group had a 1.4 times higher risk of CED compared to the highest group. The risk was also higher in the lower-middle (1.3 times), middle (1.2 times), and upper-middle (1.2 times) groups. Lastly, limited access to healthcare services increased the risk by 1.1 times (Table. 3).

Table 1. Results of Bivariate Analysis of Risk Factors for Chronic Energy Deficiency among Adolescent Girls (10–19 Years) in Indonesia (n = 55,506)

Variable	Chronic Energy Deficiency				*P-Value*	POR (CI 95%)
	CED		Not CED			
	n	%	n	%		
Age						
10-14 Years	15737	53,1	13912	46,9	0,000	1,821 (1,721-1,928)
15-19 Years	9905	38,3	15949	61,7		Reff
Education						
Low	23826	47,9	25953	52,1	0,000	1,975 (1,794-2,174)
High	1817	31,7	3909	68,3		Reff
Occupation						
Not Working	24933	46,9	28278	53,1	0,000	1,969 (1,698-2,282)
Working	709	30,9	1584	69,1		Reff
Marital Status						
Single	25350	46,5	29218	53,5	<0,001	1,807 (1,448-2,254)
Married	13	17,8	62	82,8	0,063	0,450 (0,194-1,044)
Was Married	279	32,4	581	67,6		Reff
Residence						
Rural	10575	49,8	10680	50,2	<0,001	1,261 (1,186-1,340)
Urban	15067	44,0	19182	56,0		Reff
Number of Families						

Variable	Chronic Energy Deficiency				*P-Value*	POR (CI 95%)
	CED		Not CED			
	n	%	n	%		
Big	10037	48,3	10756	51,7	<0,001	1,143 (1,076-1,213)
Normal	15605	45,0	19106	55,0		Reff
Infectious Disease						
Yes	1376	44,5	1716	55,5	0,232	0,093 (0,825-1,048)
No	24267	46,3	28146	53,7		Reff
Non-Infectious Disease						
Yes	430	46,4	496	53,6	0,930	1,010 (0,809-1,260)
No	25212	46,2	29366	53,8		Reff
Age of Menarche (n=14333)						
Slow	1246	43,6	1609	56,4	<0,001	1,418 (1,274-1,579)
Normal	3594	43,7	4636	56,3	<0,001	1,420 (1,300-1,551)
Fast	1146	35,3	2100	64,7		Reff
Physical Acticity						
Heavy	9892	44,1	12550	55,9	<0,001	0,863 (0,809-0,921)
Moderate	4787	47,4	5304	52,6	0,778	0,989 (0,92-1,071)
Light	10962	47,7	12007	52,3		Reff
Fruit and Vegetables Consumption						
Not Good	25384	46,3	29416	53,7	0,001	1,486 (1,168-1.890)
Good	259	36,7	446	63,3		Reff
Personal Hygiene						
Not Good	13616	46,3	15784	53,7	0,742	1,010 (0,953-1,071)
Good	12026	46,1	14078	53,9		Reff
Environmental Sanitation						
Not Good	10923	46,7	12449	53,3	0,221	1,038 (0,978-1,102)
Goood	14719	45,8	17413	54,2		Reff
Social Economic						
Bottom	3947	50,5	3863	49,5	<0,001	1,460 (1,330-1,603)
Lower Middle	5864	48,9	6138	51,1	<0,001	1,365 (1,246-1,496)
Middle	4973	46,0	5831	54,0	<0,001	1,219 (1,112-1,336)
Higher Middle	5942	45,9	7005	56,1	<0,001	1,212 (1,109-1,362)
Highest	4914	41,2	7023	58,8		Reff
Access to Health Facilities						
Difficult	2797	49,6	2839	50,4	0,001	1,165 (1,064-1,277)
Easy	22846	45,8	27023	54,2		Reff

Source: Processed Secondary Data, 2023

The variables non-communicable diseases and personal hygiene were not included as candidates for multivariate analysis. Additionally, the variable age at menarche was excluded due to sample size discrepancies. In this study, age 10–14 years was identified as the dominant factor, with a 1.4 times higher risk of experiencing CED compared to adolescent girls aged 15–19 years. Adolescent girls with low education levels had a 1.2 times higher risk of CED compared to those with higher education. Similarly, unemployed girls were 1.2 times more

likely to experience CED than their employed counterparts. The study also found that girls who had never been married had a 1.3 times higher risk, while those who had ever been married were found to be protective against CED compared to those currently married.

Girls living in rural areas had a 1.2 times higher risk of experiencing CED compared to those in urban areas. Additionally, girls from larger households had a 1.1 times higher risk compared to those from smaller families. Heavy physical activity was found to be protective, while moderate physical activity posed a slightly increased risk (1.0 times) of experiencing CED compared to light physical activity. Girls with poor fruit and vegetable intake were 1.3 times more likely to experience CED compared to those with good intake. Those in the lowest socioeconomic quintile had a 1.2 times higher risk, followed by lower-middle (1.3 times), middle (1.1 times), and upper-middle (1.1 times), all compared to the highest socioeconomic group (see Table 4).

Table 4. Final Multivariate Analysis Model of Chronic Energy Deficiency among Adolescent Girls (10–19 Years) in Indonesia

No	Variabel	B	*P-Value*	PR	95% CI
1	Age (10-14 Years)	0,357	0,000	1,430	1,367-1,495
2	Education (Low)	0,232	<0,001	1,261	1,157-1,374
3	Occupation (Not Working)	0,230	<0,001	1,258	1,108-1,429
4	Marital Status Single	0,311	<0,001	1,365	1,137-1,638
	Was Married	-0,721	<0,001	0,486	0,227-1,043
5	Residence (Rural)	0,116	<0,001	1,123	1,073-1,176
6	Number of Families (Big)	0,093	<0,001	1,097	1,051-1,144
7	Physical Activity Heavy	-0,048	0,047	0,953	0,909-0,999
	Physical Activity Moderate	0,018	0,047	1,018	0,962-1,078
8	Fruit and Vegetables Consumption (Not Good)	0,262	0,007	1,299	1,073-1,573
9	Social Economy Families in 1 Quintil	0,262	<0,001	1,254	1,168-1,345
	Social Economy Families in 2 Quintil	0,210	<0,001	1,233	1,151-1,321
	Social Economy Families in 3 Quintil	0,129	<0,001	1,137	1,061-1,219
	Social Economy Families in 4 Quintil	0,141	<0,001	1,152	1,078-1,231

Source: Processed Secondary Data, 2023

DISCUSSION

Based on the results of this study, 46.2% of adolescent girls in Indonesia were found to be suffering from Chronic Energy Deficiency (CED). This figure differs from the findings in the 2023 Indonesian Health Survey (SKI). The CED rate among adolescent girls is categorized as high (>20%) and has not yet reached the government's target of <5%. The proportion of adolescent girls experiencing CED in 2023 increased by 36.3% compared to 2018. Comparative studies conducted in other developing countries have shown that CED remains a major nutritional problem globally.

Research by Dagne et al. (2021) found that the prevalence of CED in Ethiopia was 28.7%, with the majority affected being women aged 18–29 years, which indicates that adolescent girls are a group vulnerable to nutritional problems, particularly CED (10). In India, CED remains relatively high, affecting around 24% of women (11). Compared to Indonesia, where the CED prevalence among adolescent girls reaches 46.6%, this indicates a more severe problem. Given this situation, the issue of CED should be a priority for the government, especially in reducing the prevalence among adolescent girls.

The results also showed that adolescent girls with low educational attainment had a 1.2 times higher risk of experiencing CED compared to those with higher education. This finding aligns with research by Tafasa et al. (2022), which stated that adolescent girls with low education levels had a 1.8 times higher risk of CED (12). This is because higher education increases understanding and access to health-related information, including nutritional needs. Kendel Jovanović et al. (2023) noted that individuals with higher education levels experience improved nutrition knowledge, dietary quality, and health behaviors, leading to better nutritional status in school-age children (13). Therefore, families should be encouraged to support government programs such as KIP (Kartu Indonesia Pintar) to ensure access to quality education and health knowledge. Schools can also provide nutrition education through health units such as UKS.

This study's analysis also shows that adolescent girls who are not employed have a 1.25 times higher risk of experiencing CED compared to those who are employed. This is consistent with the findings of Purwanto et al. (2020), who stated that women who are not employed were 17.5 times more likely to experience CED compared to women who are employed (14).

Unemployed women may have fewer opportunities for social interaction, which limits their access to health-related information. Employed adolescent girls who study and work may experience dual workloads within a limited time, but in lower-income families, adolescents who work and earn income may be able to afford more food. On the other hand, those who are not employed are dependent on their families to fulfill their nutrition and health needs, thus having less autonomy in making personal health decisions. (15). Therefore, several measures may help adolescent girls maintain their nutritional status, including participation in adolescent nutrition programs organized by BKKBN (National Population and Family Planning Agency) through posyandu (community health posts) and school programs that provide information on balanced nutrition.

The multivariate test results also show that adolescent girls who are not yet married have a 1.3 times higher chance of experiencing CED, while those who have ever been married have a 0.4 times lower risk of experiencing CED compared to married adolescent girls. A previous study conducted by Abdu et al. (2018) stated that one of the most influential factors in undernutrition or CED among women is marital status, where never-married women had an 8.6 times higher risk of being undernourished compared to married women (AOR = 8.58, 95% CI: 2.98–24.73) (16).

Women who are single—either never married or previously married—generally pay more attention to their appearance or body image, making them more prone to eating disorders, such as dieting to lose weight (17). Adolescent girls with negative body image often feel dissatisfied with their body shape. Consequently, many engage in diets or reduce food intake to appear thinner or to achieve a desired body shape, and this prolonged insufficient intake may lead to CED (18). For unmarried adolescent girls, CED can be prevented by consuming nutritious and balanced food and avoiding risky diets. Additionally, participating in programs conducted by Puskesmas (community health centers) such as PMT (Supplementary Feeding Program) for adolescents can help increase their nutritional intake.

This study also shows a significant association between place of residence and CED, where adolescent girls living in rural areas have a 1.1 times higher risk of experiencing CED

than those in urban areas. A similar study by Negash et al. (2020) reported that rural adolescent girls had a 1.69 times higher risk of being underweight compared to urban girls (19).

Urban areas tend to have higher levels of food consumption, while rural communities may maintain simpler consumption patterns based on traditional diets. Adolescent girls in rural areas are also more likely to experience food insecurity, limited access to health services, and less awareness of healthy lifestyles and proper dietary patterns (20). Therefore, adolescents should be encouraged to participate in programs such as BKKBN's Healthy Kitchen Against Stunting, which should be expanded not only to pregnant women and at-risk families, but also to adolescents.

This study also demonstrates that adolescent girls from larger households have a 1.09 times higher risk of experiencing CED compared to those from smaller families. Sumbolon, Lorena, and Nathan (2024) stated that women from large families were 2 times more likely to experience CED than those from smaller households (21). In addition, previous studies have also indicated a relationship between the incidence of underweight and the number of household members (household size) (22).The greater the number of family members, the more difficult it becomes to ensure adequate nutrition for each individual. Adolescent girls in large households often share food portions, which may result in inadequate intake (23). On the other hand, smaller households find it easier to meet nutritional needs. This issue can be addressed by participating in family planning (KB) programs, which not only help reduce birth rates but also ease the economic burden, particularly in terms of food provision.

This study found a relationship between physical activity and CED. Heavy physical activity has a protective effect, reducing the likelihood of CED (PR = 0.953, 95% CI: 0.909–0.999). On the other hand, adolescent girls who engage in moderate activity have a slightly increased risk (PR = 1.018) compared to those doing light activity. Hartini et al. (2022) stated that adolescent girls who do not engage in sufficient physical activity have a 2.4 times higher risk of experiencing CED compared to those who are active enough (24).

Physical activity can determine an individual's health status. Inadequate food intake combined with insufficient physical activity over a prolonged period can negatively impact adolescent development. Excessive physical activity without balanced nutrition may lead to a thin body type or nutrient deficiency (24). Adolescents can join programs such as GERMAS (Healthy Living Community Movement) organized by local health institutions. However, it is important to note that excessive physical activity without sufficient nutrient intake can increase the risk of CED.

The study also shows that poor fruit and vegetable consumption increases the risk of CED by 1.29 times. This aligns with a study by Abdindra SA, Novianty, and Garmini R (2025), which found a significant relationship between fruit and vegetable consumption and CED (P = 0.005), where adolescent girls who did not consume enough fruits and vegetables had an 8.4 times higher risk of CED (25). Vegetables and fruits are food sources rich in essential nutrients and bioactive compounds required for daily bodily functions (26). Inadequate intake of these foods leads to deficiencies in vitamins, minerals, and fiber, increasing the risk of illness and both undernutrition and overnutrition. To address this, the government has launched programs such as GERMAS and Isi Piringku (My Plate) to help adolescent girls understand the

importance of consuming sufficient fruits and vegetables. Lack of these foods makes adolescent girls more vulnerable to nutrient deficiencies.

The analysis also shows that adolescent girls from low-income families (lowest socioeconomic quintile) have a 1.25 times higher risk of CED, followed by those in the lower-middle (1.23 times), middle (1.13 times), and upper-middle (1.15 times) quintiles. Singh JK et al. (2021) stated that adolescent girls from low-income families had a 2.48 times higher risk of CED compared to those from high-income families (27).

Nutritional problems have long been associated with poverty, as poor nutritional status—including CED—is more common in low-income households. The effects of poverty on individuals are reflected in various forms, including food insecurity, higher disease risk, reduced productivity, and stunted physical and intellectual development (28). Low socioeconomic status leads to low purchasing power, especially for nutritious food, which can result in both macro- and micronutrient deficiencies. Often, money that should be used for nutritious food is redirected toward other household needs.

Adolescent girls aged 10–14 years are 1.43 times more likely to experience CED than those aged 15–19 years, even after controlling for variables such as education, employment, marital status, place of residence, household size, infectious diseases, physical activity, fruit and vegetable consumption, environmental sanitation, and socioeconomic status. This finding is consistent with the study by Maretalinia et al. (2020), which stated that adolescent girls aged 11–15 years were 2.38 times more likely to experience CED than those aged 16–18 years (29).

Adolescent girls aged 10–14 years are more vulnerable to nutritional problems due to a higher likelihood of eating disorders, such as anorexia, bulimia nervosa, and binge-eating disorder. These disorders are often linked to adolescents' desire to conform to prevailing beauty standards. Additionally, girls in this age group have higher nutritional needs due to rapid physical and emotional development, compared to those aged 15–19 years. Older adolescents are generally more capable of distinguishing between nutritious and non-nutritious food choices, which also affects their nutritional status (30).

This study has several limitations, such as respondent bias, in which respondents may provide answers that are dishonest or aligned with what they believe the researchers expect. Additionally, there are semantic differences, where respondents may misinterpret the questions, which can affect the accuracy of the research findings.

CONCLUSION AND RECOMMENDATIONS

In this study, the proportion of adolescent girls aged 10–19 years in Indonesia who experienced Chronic Energy Deficiency (CED) was 46.2%. The findings indicate significant relationships between age, education, employment, marital status, place of residence, household size, age at menarche, physical activity, fruit and vegetable consumption, family socioeconomic status, and access to healthcare services with the incidence of CED among adolescent girls aged 10–19 years in Indonesia in 2023. The dominant factor in this study was age (PR = 1.430; 95% CI: 1.367–1.495), which remained significant after controlling for variables including education, employment, marital status, place of residence, household size, fruit and vegetable consumption, physical activity, and family socioeconomic status.

Therefore, it is strongly recommended that adolescent girls—especially those aged 10–14 years consistently adopt a healthy lifestyle by maintaining a balanced diet that includes adequate nutritional intake such as consuming sufficient fruits and vegetables daily, engaging in regular physical activity appropriate to their capacity and health status, practicing proper personal hygiene and maintaining good environmental sanitation. In addition, schools are expected to be able to provide education for their students about nutritions food intake. Not only that, schools can also collaborate with health institutions to help nutritions to help provide information to their students. Furthermore, it is hoped that's schools can strengthen the implementation of healthy school programs and free nutritions meal programs.

Additionally, it is expected that health institutions continue to implement and promote programs that support adolescent nutrition, such as Supplementary Feeding Programs (PMT), and routinely conduct posbindu (integrated health post) activities as part of a preventive effort against CED in this age group. Moreover, future researchers are encouraged to conduct follow-up studies using primary data, in order to explore in greater depth the relationship between the dominant factor and other contributing variables related to CED.

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