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Nutritional and Health Status of Adolescents and their Determinants in the Coastal Areas of Maratua Subdistrict, Berau Regency, East Kalimantan, Indonesia

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Abstract
Introduction: Adolescence is a critical period of growth marked by increased nutritional needs and heightened susceptibility to health problems. This study aimed to analyze the nutritional and health status of adolescents and their determinants.
Methods: A cross-sectional study was conducted among 47 tenth-grade students at SMAN 9 Berau, recruited through total sampling method. The data collected included anthropometry, blood pressure, hemoglobin levels, and urine tests. Behavioral and psychological factors were assessed using standardized questionnaires: nutrition knowledge, dietary intake (1×24-hour recall and food frequency), Pittsburgh Sleep Quality Index, screen time, and the Depression Anxiety Stress Scale. Data were analyzed descriptively and using chi-square tests.
Results: Most adolescents had a normal nutritional status (78%); however, a dual burden of malnutrition persisted, with undernutrition and overweight or obesity affecting over one-fifth of the participants. Dehydration was highly prevalent (89%) and was accompanied by significant cardiometabolic risks, including prehypertension (32%) and chronic energy deficiency risk (38%). Although the overall energy intake was adequate, the insufficient intake of key micronutrients, particularly protein, iron, and folate, remained common. Behavioral and psychosocial vulnerabilities were also prominent, with excessive screen time, poor sleep quality, and notable levels of stress and depression reported by more than half of the respondents. BMI-for-age was significantly associated with blood pressure, chronic energy deficiency risk, and nutritional knowledge ($p < 0.05$).
Conclusion: Despite a predominantly normal nutritional status, adolescents remain at risk of the double burden of malnutrition, anemia, and micronutrient deficiencies. Strengthening school-based nutrition programs, including regular health screening, practical nutrition education, and improved access to micronutrient support through fortified foods or supplements, is essential for preventing long-term health problems.

Keywords: Adolescents, nutritional status, health status, coastal area, determinants.

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Introduction

Adolescence is recognized as one of the most critical stages of physical growth and development in humans. Following early childhood, adolescence represents the most crucial period for growth and changes in body composition and physiology.[1] During this stage, the requirements for energy, protein, and other nutrients increase to accommodate the relatively rapid growth rate. Meeting the nutritional needs of adolescents is considered a key strategy to break the cycle of malnutrition, chronic diseases, and intergenerational poverty.[2]

Nutritional and health problems during adolescence significantly impact productivity, particularly in terms of education, health, and socioeconomic outcomes. Poor nutritional status can impair physical growth, cognitive development, and immune function, making adolescents more susceptible to diseases. For instance, adolescents experiencing anemia or stunting often exhibit delayed physical and mental development, which ultimately affects their academic performance.[3] Additionally, physical limitations resulting from malnutrition can restrict active participation in social and physical activities, potentially hindering the development of social skills and optimal mental health.[4] The inability to fully engage in social and academic life not only diminishes adolescents' quality of life but also reduces their opportunities to reach their full potential.

Environmental factors, such as family support, socioeconomic status, and sociodemographic characteristics, play crucial roles in determining adolescents' nutritional and health status. For example, adolescents from low-income families often face limitations in accessing nutritious food and adequate healthcare, directly affecting their nutritional status.[5] Additionally, factors such as parental education, parenting practices, and access to health information contribute to adolescents' nutritional knowledge and eating behaviors.[6] Therefore, interventions focusing on improving access to nutritious food, nutrition education, and family support are essential to address adolescent nutritional problems. Such programs are particularly necessary in vulnerable regions to enhance the health status and future productivity of adolescents.

Maratua Subdistrict in Berau Regency is one of Indonesia's outermost island regions, directly bordering the Philippine Sea, dominated by aquatic ecosystems, and rich in fisheries and marine resources that also serve as tourist attractions. According to national statistics (2023)[7], adolescents aged 12–24 years constitute the majority of the population, underscoring the critical need for in-depth research on adolescent health and nutrition in this remote island. Studies from similar island settings have demonstrated that limited dietary diversity, constrained food systems, and dependence on imported or processed foods significantly affect diet quality and increase nutritional vulnerability among children and adolescents.[8] However, there is a dearth of data on adolescent nutrition in Indonesian island environments.

To date, no study has examined the determinants of adolescent nutrition in Indonesia's outermost islands, including Maratua, which has unique socioeconomic conditions and limited healthcare access for its residents. Considering that adolescence represents the final window to optimize growth and prevent long-term health consequences, this study provides a novel contribution by evaluating the nutritional and health status of adolescents in coastal areas of Maratua Island and identifying key sociodemographic, behavioral, and physiological factors influencing it as evidence to inform more context-specific nutrition interventions in remote island settings.

Methods

Study Design and Setting

This study employed a cross-sectional design to examine the factors associated with the nutritional status of adolescents (BMI-for-age). The research was conducted at SMAN 9 Berau, Maratua Island, East Kalimantan, Indonesia, from October to November 2024.

Sampling Method and Participants

A total sampling technique was applied because of the limited population

size. All tenth-grade students (n = 47) were included in this study. Although the small sample size limits generalizability, it represents the entire study population. The inclusion criteria were tenth-grade students who were willing to participate and who provided informed consent. The exclusion criteria were absenteeism during data collection, a history of chronic diseases related to anemia, pregnancy, and lactation.

Data Collection and Measurements

Primary data were obtained using the standardized procedures.

- Anthropometry: Body weight and height were measured to calculate the BMI-for-age.
- Physiological factors: Blood pressure was measured using a digital sphygmomanometer (Omron®), hemoglobin levels were assessed with Hemocue®, hydration status was assessed using a urine reagent strip (OneMed®), and dysmenorrhea status was recorded.
- Behavioral factors were assessed using validated instruments. Dietary intake was measured using a 24-hour dietary recall with a food model book and probing techniques to reduce recall bias, and a FFQ for habitual intake. Sleep quality and screen exposure were evaluated using the PSQI and WHO Screen Time Questionnaire. Additional behaviors such as smoking, meal skipping, physical activity, water intake, body image perception, iron supplementation adherence, and healthy lifestyle practices were recorded. The PSQI and DASS-42 were previously culturally adapted and validated for Indonesian adolescents.
- Psychological factors: Stress levels were assessed using the Depression, Anxiety, and Stress Scale (DASS-42).
- Sociodemographic factors were collected using a structured questionnaire covering economic status, marital status, academic performance, and nutrition knowledge.

Data Analysis

Data were analyzed using the IBM SPSS version 20 (Chicago, Armonk, NY, USA). Descriptive statistics were used to summarize the respondents' characteristics and nutritional status. Chi-square tests were performed to examine the association between BMI-for-age categories and the independent variables. Statistical significance was set at $p < 0.05$.

Ethics Approval and Consent to Participate

This study was approved by the Health Research Ethics Committee of the Faculty of Dentistry, University of Jember (approval number: 2849/UN25.8/KEPK/DL/2024). Written informed consent was obtained from all participants and their parents/guardians prior to the study.

Results

Respondent Characteristics

Among the 47 respondents, the majority were aged 15–16 years (76.6%) and female (66%), placing them in a critical growth phase and making them vulnerable to iron deficiency anemia in the post-menarche phase. Parental education was relatively low; combined, 55.3% of mothers and 57.5% of fathers had only completed primary or junior high school. Previous studies have shown that maternal education at this level is associated with a 1.5-fold higher risk of stunting[9], indicating that adolescents in Maratua are in a high-risk group. Economically, 65.9% of families earned less than IDR 2,000,000 per month, and most respondents (57.4%) came from large families, which may reduce per capita food allocation and exacerbate the nutritional vulnerability of adolescents.

Distribution of Nutritional Status and Adolescent Health Factors

Although most adolescents in Maratua had a normal nutritional status (78%), several health issues were observed. The most critical finding was the very high prevalence of dehydration, with 44.7% classified as dehydrated and 44.7% as very dehydrated, totaling 89.4% of adolescents. Additionally, 25.5% experienced moderate to severe anemia, with 9 students experiencing moderate

anemia and 3 experiencing severe anemia. Furthermore, 38.3% were at risk of chronic energy deficiency and 31.9% exhibited pre-hypertension. These findings indicate that despite a generally adequate nutritional status, major health risks, particularly dehydration, moderate-to-severe anemia, and early indicators of chronic energy deficiency, remain significant concerns in this population.

Adolescent Dietary Patterns

The average energy intake of adolescents in Maratua reached 87.36% of the recommended dietary allowance (RDA), whereas their carbohydrate intake was approximately 83.85%. However, protein (68.64%) and fat (78.79%) intakes were below the recommended levels. These results indicate that although energy requirements are relatively met, diet quality is suboptimal, particularly regarding macronutrients that are essential for muscle growth and development. Individual consumption varied considerably, as reflected by the large standard deviations, suggesting that some adolescents had intake far below the average.

Association of BMI-for-Age with Health, Sociodemographic, and Psychological Variables Based on Chi-Square Test

The Chi-square test results indicated significant associations between BMI-for-age and hypertension status (χ^2 = 18.505; p = 0.005), MUAC status as an indicator of chronic energy deficiency (χ^2 = 8.107; p = 0.044), and nutrition knowledge level (χ^2 = 12.826; p = 0.046) (Table 4). Adolescents with abnormal BMI-for-age were at a higher risk of hypertension, consistent with previous reports[10,11] that highlighted obesity as a determinant of elevated blood pressure. The association with chronic energy deficiency supports previous findings[12], indicating that chronic energy deficits reduce physical fitness and increase the metabolic vulnerability. Low nutritional literacy aligns with previous findings[13], although it contrasts with other studies[14] that showed that knowledge does not always translate into healthy eating practices. These physiological mechanisms suggest that abnormal BMI-for-age may influence blood pressure either through obesity or energy deficiency, which compromises metabolic capacity.

Table 1. Respondent Characteristics

Characteristic	Frequency	Percent (%)
Age		
14 years	1	2.1
15 years	16	34.0
16 years	20	42.6
17 years	10	21.3
Sex		
Male	16	34.0
Female	31	66.0
Father's Education		
No formal education	4	8.5
Primary school/equivalent	14	29.8
Junior high school/equivalent	13	27.7
Senior high school/equivalent	11	23.4
Bachelor's degree (S1)	5	10.6
Mother's Education		
No formal education	4	8.5
Primary school/equivalent	15	31.9
Junior high school/equivalent	11	23.4
Senior high school/equivalent	12	25.5
Diploma (D1/D2/D3)	1	2.1
Bachelor's degree (S1)	4	8.5

Characteristic	Frequency	Percent (%)
Family Income		
< IDR 500,000	8	17.0
IDR 500,000–999,999	12	25.5
IDR 1,000,000–1,999,999	11	23.4
IDR 2,000,000–2,999,999	10	21.3
IDR 3,000,000–4,999,999	2	4.3
≥ IDR 5,000,000	4	8.5
Family Type		
Small family	20	42.6
Large family	27	57.4
Total	47	100

Table 2. Nutritional Status and Determinants of Adolescent Health

Variable	Category	Frequency	Percent (%)
Nutritional Status	Underweight	4	8
	Normal	39	78
	Overweight	3	6
	Obese	4	8
Anthropometry	Normal MUAC	29	61.7
	At Risk of Chronic Energy Deficiency	18	38.3
Blood Pressure	Normal	32	68.1
	Pre-hypertension	15	31.9
Hydration Status	Mildly dehydrated	5	10,6
	Dehydrated	21	44,7
	Very dehydrated	21	44,7
Nutrition Knowledge	Poor	35	74.5
	Moderate	6	12.8
	Good	6	12.8
Physical Activity	Inactive	2	4.3
	Light	25	53.2
	Moderate	13	27.7
	Vigorous	7	14.9
Sleep Quality	Good	13	27.7
	Poor	34	72.3
Screen Time	Normal	21	44.7
	Excessive	26	55.3
Water Consumption	Adequate	31	66.0
	Inadequate	16	34.0
Body Image	Positive	28	59.6
	Negative	19	40.4
Stress	Normal	8	17.0
	Moderate	37	78.7
	Severe	2	4.3
Anxiety	Normal	37	78.7
	Moderate	8	17.0
	Severe	2	4.3
Depression	Normal	17	36.2
	Moderate	30	63.8

Variable	Category	Frequency	Percent (%)
Anemia in Female Adolescents	Non-Anemia	14	45.2
	Mild Anemia	6	19.4
	Moderate Anemia	8	25.8
	Severe Anemia	3	9.7
Anemia in Male Adolescents	Non-Anemia	8	50.0
	Mild Anemia	7	43.8
	Moderate Anemia	1	6.3

Table 3. Adolescent Dietary Patterns

Category	Nutrient Intake	Nutrient Adequacy Level
	Mean ± SD	Mean ± SD
Energy	2119.15 ± 488.738	87.36 ± 19.14
Carbohydrates	262.34 ± 49.463	83.85 ± 13.27
Protein	50.91 ± 13.831	68.64 ± 20.10
Fat	66.04 ± 20.673	78.79 ± 19.27
Folic Acid	321.06 ± 114.990	60.15 ± 13.11
Iron	13.59 ± 4.304	60.36 ± 15.13

Table 4. Association of BMI-for-Age with Respondents' Health, Sociodemographic, and Psychological Variables Based on Chi-Square Test

Variable	χ^2 Value	p-value
Hypertension Status	18.505	0.005
Haemoglobin Category (Anemia)	7.093	0.069
MUAC Category (Chronic Energy Deficiency)	8.107	0.044
Urine Color Category (Dehydration)	6.839	0.336
Father's Education Status	8.482	0.205
Mother's Education Status	9.004	0.173
Income Status	2.850	0.415
Family Type	7.229	0.065
Nutrition Knowledge Category	12.826	0.046
Body Image Status	3.517	0.319
Screen Time Category	0.811	0.847
Sleep Duration Category	2.576	0.462
Sleep Quality	6.670	0.083
Food Consumption	4.691	0.196
Physical Activity Category	5.826	0.757
Depression Category	0.558	0.906
Anxiety Category	6.779	0.342
Stress Category	6.779	0.342
Motivation	18.202	0.110
Energy (kcal)	64.320	0.100
Carbohydrate (g)	57.880	0.554
Protein (g)	80.509	0.108

Discussion

The findings of this study demonstrate that the nutritional status of adolescents in Maratua is influenced by a complex interplay of sociodemographic, behavioral, psychological, and physiological factors. Consistent with previous reports[3], children born to mothers with low educational attainment are at a greater risk of suffering malnutrition. However, in contrast to Hidayati[15], who reported no significant association, the present study highlights the importance of local contextual factors such as limited food access, dietary culture, and school-based programs. In Maratua, a remote outer island, the restricted distribution of fresh food and reliance on seafood represent unique determinants that must be considered when designing nutritional interventions for the local population.

From a behavioral perspective, the majority of adolescents exhibited low nutritional knowledge (74.5%), poor sleep quality (72.3%), and excessive screen time (55.3%), whereas most reported adequate water intake (44.7%) and a positive body image (59.6%). These behavioral patterns increase the risks of undernutrition, dehydration, and stress. In particular, dehydration and prolonged screen exposure can disrupt sleep quality, further contributing to elevated stress and depression levels.[16,17] The psychological burden was considerable, with 78.7% of adolescents experiencing moderate stress and 63.8% experiencing moderate depression. These findings are consistent with studies showing associations between low nutritional literacy, sedentary lifestyles, and adverse mental health outcomes.[18] Moreover, the relatively high prevalence of pre-hypertension observed in this study may reflect contextual influences such as high salt consumption and limited physical activity.[19] Taken together, these results indicate that adolescent health in Maratua is shaped by interconnected behavioral and psychological risk factors.

Nutrient deficiencies provide further evidence of this vulnerability among children. The most significant deficiencies were observed in folate (60.15%) and iron (60.36%), both of which are essential for growth, cognitive development, and anemia prevention. Iron deficiency impairs physical capacity and concentration, whereas folate deficiency compromises DNA synthesis and red blood cell formation, leading to anemia. Local dietary patterns dominated by rice, bread, and noodles with limited intake of animal protein and leafy green vegetables illustrate a form of hidden hunger, where the caloric intake is adequate, but micronutrient needs remain unmet. These findings align with previous reports from developing countries[20], although they differ from studies suggesting that energy adequacy alone does not guarantee optimal nutritional status due to the mediating influences of physical activity and metabolism.[21] In the context of Maratua, limited dietary diversity and restricted access to nutrient-dense foods are the primary determinants of adolescent dietary patterns.

The chi-square analysis further revealed that while some associations were significant, other variables such as anemia ($p = 0.069$), family type ($p = 0.065$), sleep quality ($p = 0.083$), energy intake ($p = 0.100$), protein intake ($p = 0.108$), and sociodemographic, behavioral, and psychological factors were not statistically significant. This suggests that physiological and cognitive factors may play a stronger role in determining nutritional outcomes than social and psychological influences. The lack of statistical significance may be attributable to the small sample size, homogeneity of the categories, and limitations in the sensitivity of the measurement tools.

Overall, these findings underscore the urgent need for integrated interventions targeting adolescents with abnormal BMI-for-age values. Recommended strategies include early detection of hypertension, prevention of chronic energy deficiency through supplementation and dietary diversification, and strengthening nutritional literacy via school-and family based programs. Furthermore, combining

nutrition and hydration education, structured physical activity, iron–folate supplementation, and school-based mental health screening can reduce the risk of chronic energy deficiency, anemia, dehydration, and psychological disorders. Such a comprehensive approach has the potential to foster sustainable, healthy lifestyle behaviors and support optimal adolescent growth and development, particularly in remote island settings such as Maratua, where access to nutritious food and health care services is limited. Strengthened coordinated efforts between local health offices, schools, and families are essential to implement comprehensive interventions encompassing practical nutrition education, micronutrient supplementation, hydration promotion, enhanced physical activity, and mental health support to improve adolescent health outcomes in Maratua.

Limitations of the Study

This study had some limitations. The small sample size (n=47) limits generalizability. The cross-sectional design of this study does not allow for causal inferences. Dietary intake was assessed using a single 24-hour recall, which may be subject to a recall bias. Despite these limitations, the findings provide insights into the nutritional and health status of adolescents in remote island settings.

Conclusion

Most adolescents in the coastal areas of Maratua exhibited normal nutritional status, although cases of undernutrition and excess weight were also identified. Physiological determinants, including blood pressure, MUAC, hemoglobin levels, and nutritional literacy, were the primary predictors of nutritional status. Risk behaviors, such as prolonged screen time, inadequate sleep quality, and insufficient protein and micronutrient intake, indicate vulnerability to hidden hunger. Although psychological and sociodemographic factors were not significantly associated, targeted interventions are essential to address these issues. Strengthening school- and community-based programs that include routine iron and folate supplementation, practical nutrition literacy initiatives, hydration promotion, increased opportunities for physical activity, and enhanced mental health support is crucial for improving the health of adolescents. These recommendations provide an evidence-based foundation for developing sustainable adolescent health policies in remote island settings with limited access to healthcare services, such as Maratua Island.

Ethics approval

This study was approved by the Health Research Ethics Committee of the Faculty of Dentistry, University of Jember (approval number: 2849/UN25.8/KEPK/DL/2024). Written informed consent was obtained from all participants and their parents/guardians prior to the study.

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available because of access limitations and the need to protect participants' privacy. However, they are available from the corresponding author upon reasonable requests.

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Author Contribution

JA conceived the study and wrote the first version of the manuscript. I, ELS, IWW, ATK, MNAAS, RMSG, CMM, KA, and UK collected the data. FR and ARM analyzed and interpreted the obtained data. MF critically revised and approved

the final manuscript. All authors have read and approved the final manuscript.

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