Journal of Indonesia Applied Nutrition
1(2):165-174, 2026, https://doi.org/10.56303/jian.v1i2.1604
E-ISSN: 3125-1188, https://www.journalmpci.com/index.php/jian

Macro-Micronutrient Intake and Nutritional Status among School-age Children: A Cross-Sectional Analysis of Primary Schools in Kediri City

Dzakiyyatul Fikrah 'Arifah[1*], Yayuk Farida Baliwati[2], Ali Khomsan[2]

[1] Nutrition Study Program, Faculty of Medicine, Universitas Negeri Semarang, Semarang, Indonesia, 50237
[2] Faculty of Medicine and Nutrition, IPB University, Bogor, Indonesia, 16680

Corresponding Author's Email: dzakiyyatulfikrah@mail.unnes.ac.id

ARTICLES

Submitted: Jul 10, 2026

Accepted: Aug 10, 2026

Keywords:
Individual double burden of malnutrition, Nutrition, Nutritional status, Nutrient intake, School-age children

ABSTRACT

School-age children represent a critical phase for physical development, cognitive growth, and bone mineralization, a period that is frequently overlooked in nutritional research compared to early childhood. This study aims to map macro- and micronutrient intakes and their relationship with nutritional status among primary school children in Kediri City to establish a foundation for nutritional education interventions. This cross-sectional study involved 80 subjects selected via purposive sampling across two primary schools. Data were gathered through subject characteristic questionnaires, 24-hour dietary recalls conducted over two days (representing weekdays and weekends), and direct anthropometric measurements to determine nutritional status. Data were analyzed descriptively and inferentially using the Chi-square test to examine relationships between variables. This study reveals striking paradox of the phenomenon of individual double burden of malnutrition in school-aged children in Kediri City. More than a half of children categories as abnormal (51.2%) dominate with obesity (68.3%) and overweight (29.3%). Paradoxically, almost all of the macronutrient suboptimal, micronutrient deficient, and showed no significant association with the children's anthropometric status within the children's. This relationship presents a potential scenario where overnutrition occurs but consumption is inadequate. Associations were found only between nutritional status and protein intake (p = 0.029) where significantly associated with a child's physical profile during this development period. Integrated nutritional education interventions are urgently required to improve dietary consumption patterns and ensure children achieve their optimal growth potential before reaching adulthood.

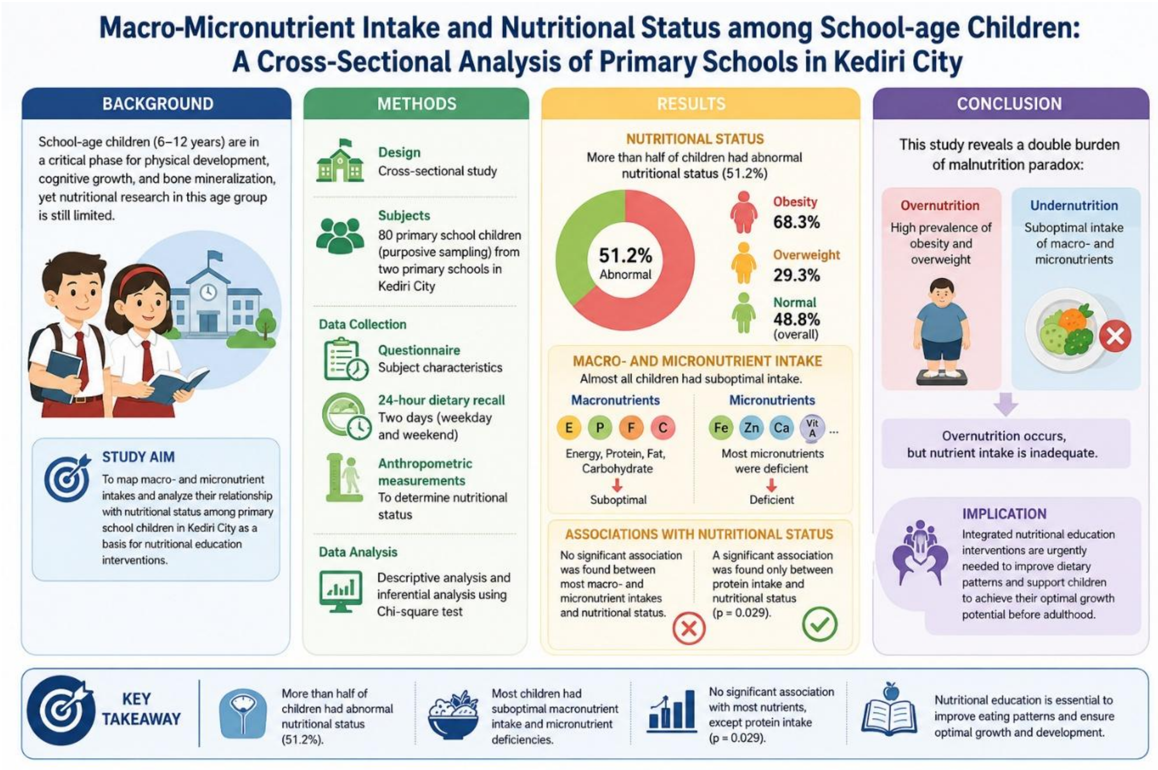
Access this article online

Quick Response Code

Key Messages:

- School-age years represent a critical window for catch-up growth before reaching adulthood maturity.
- During school age, macro-micronutrients are crucial since this is a period of second window development.
- The phenomenon of double burden malnutrition in individual level was observed, a condition characterized by the coexistence of obesity and micronutrient deficiencies.

GRAPHICAL ABSTRACT



INTRODUCTION

Middle childhood and early adolescence, generally encompassing school-age children (5–15 years), have received disproportionately less scientific attention compared to the first 1,000 days of life (1). This is partly driven by the perception that the impacts of early childhood nutritional deficits are irreversible, leading to the misconception that the school-age period is less "decisive." In fact, this phase represents a critical bridge to adulthood, characterized by various transformative biological, cognitive, and psychosocial inflection points. Preadolescence (around nine years of age) serves as a critical turning point; it is a vulnerable yet malleable period for irritability trajectories due to rapid biological and social changes, thereby offering a key window for targeted interventions (2). During this period, the body has an opportunity for catch-up growth, a condition where the body accelerates growth velocity to return to its predetermined canalized trajectory, which is heavily influenced by the timing, severity, and duration of the prior nutritional insult (3). Consequently, adequate nutrition during this phase does not merely support ongoing growth, but also acts as a "final window of opportunity" to rectify past developmental deficits and mitigate long-term health risks associated with overnutrition. This age range also marks the onset of adiposity rebound, an increase in body fat that serves as a physiological preparation before entering the pubertal growth spurt, particularly for girls approaching menarche (3).

Optimal development, health, and academic achievement in children are profoundly dependent on proper nutrient fulfillment (4). Children require proportionally higher and more specific nutrient intakes than adults because they are undergoing massive growth processes of bone, teeth, muscle, and blood volume (3). Physiologically, the school-age period is characterized by dynamic growth adjustments. This period involves accelerated bone mineralization, during which over 80% of adult bone mass is accumulated, alongside peak brain development within the prefrontal cortex, the region responsible for executive functions and decision-making (1). As a result, inadequacies in macro- and micronutrients, such as protein, iron, zinc, and calcium, can severely hinder physical growth potential and neural maturation. For instance, iron deficiency in school-age children has been proven to impair cognitive performance and academic achievement, ultimately exerting a negative impact on adulthood productivity (5). Currently, the latest national data from 2023 indicates that the prevalence of anemia in Indonesia among the 5–14 age group stands at 16.3% (6). This high prevalence of anemia among school-age children warrants serious attention, given that the structural and functional development of their brains is still

https://doi.org/10.56303/jian.v1i2.1604

actively progressing (7).

At the global level, the nutritional challenges facing school-age children have shifted toward the double burden of malnutrition (8,9). Stunting and micronutrient deficiencies now coexist with a rapidly rising prevalence of obesity, particularly in low- and middle-income countries (10). Many children enter school with a seemingly normal nutritional status at age five, but their condition deteriorates throughout their school years due to an unsupportive food environment and a lack of nutritional literacy (1). Therefore, comprehensive interventions are required, targeting not only food provision but also behavioral modifications leveraged through school education platforms. Because nutritional issues are multifactorial, collaboration across various stakeholders is imperative. In Canada, for example, provincial governments, territorial authorities, and school boards hold full responsibility for designing policies and providing integrated nutritional service programs in schools (4).

Indonesia, particularly urban areas such as Kediri City, faces similar challenges in mapping childhood nutritional status amidst dynamic lifestyle shifts. The 2023 national data shows that children aged 5–12 years in Indonesia experience a stunting prevalence of 14.1%, thinness at 7.5%, overweight at 11.9%, and obesity at 7.8% (6). In line with this national trend, the prevalence of suboptimal nutritional status among children in Kediri City remains notably high. Based on 2018 data, 15.8% of children aged 5–12 years in this city were overweight, 12.4% were obese, 7.0% were thin, 8.8% were severely stunted, and 4.5% were stunted (11). Kediri City was strategically selected as the study site due to its high burden of childhood overnutrition, which exceeds both national and provincial averages. Specifically, overweight and obesity rates in Kediri are notably higher than national figures. Furthermore, while East Java ranks third nationally for overnutrition prevalence, Kediri holds the fourth-highest position among cities within the province, making it a critical urban case study for this nutritional transition.

Achieving optimal nutritional status is not an instantaneous process; rather, it is the cumulative result of long-term strategies in dietary selection, which subsequently enhances overall quality of life (12). While nutrition research in Indonesia largely focuses on the first 1,000 days of life, this study shifts its focus to school-age children, identifying this phase as a crucial and final window of opportunity to catch-up growth. This is a crucial period for correcting past developmental deficits before reaching adult maturity. By providing a potrait of an urban setting in Kediri City, this study aims to analyze the relationship between macronutrient and micronutrient intake and nutritional status in school-age children.

METHODS

This study utilized a cross-sectional design. The data employed in this study served as baseline data from a quasi-experimental research project titled, "Maternal Nutritional Education and Its Impact on Improving Food Consumption of School-age Children: A Social Cognitive Theory Approach." The target population comprised primary school students. Samples were selected using a purposive sampling technique based on predefined inclusion criteria. The research was conducted at two primary schools located in Kediri City, East Java. The subjects were primary school students ranging in age from 9 to 11 years. Subject selection took into consideration enrollment in the Phase I "School Mover" (Sekolah Penggerak) program, recommendations from the local education office, school cooperation, and written informed consent provided by the children's parents or guardians. A minimum sample size of 40 students per school was determined using G*Power software (version 3.1), calibrated according to parameters established in prior literature (13).

The dataset utilized in this analysis included subject characteristics, dietary nutrient intake levels, and nutritional status. Data were collected via structured questionnaires, 24-hour dietary recalls (administered twice), and direct anthropometric measurements. Subject characteristics included sex and age. Anthropometric evaluations were conducted directly to determine the nutritional status of the children. Stature was measured duplicate using a stadiometer (Microtoise). Body weight was recorded duplicate using a digital scale. Anthropometric data were subsequently used to calculate BMI-for-age Z-scores (BAZ) in accordance with the Anthropometric Standards of the Indonesian Ministry of Health (14). The children's nutritional status was classified into two distinct categories: (1) abnormal nutritional status encompassing by thinness ($-3 \leq$ Z-score $<$ -2), overweight ($1 <$ Z-score ≤ 2), and obesity (Z-score > 2); and (2) normal nutritional status by normal weight ($-2 \leq$ Z-score ≤ 1).

Data was collected by enumerators who were nutrition graduates and had been briefed before data collection. When conducted interviews, the enumerators were assisted with household units of measurement and food photo books were used. Mothers accompanied the children taking part in this 24-hour food recall. The 24-

https://doi.org/10.56303/jian.v1i2.1604

hour dietary recall data were collected over two non-consecutive days, representing both a weekday and a weekend. Food consumption data from these two days were analyzed using the Indonesian Food Composition Table (TKPI) to quantify individual macro- and micronutrient intakes. The values from both days were then averaged to determine the mean daily macro- and micronutrient intake for each child. Macronutrient adequacy was calculated as the ratio of the child's actual intake relative to their individual requirement. Individual energy requirements were computed using the Estimated Energy Requirement (EER) formula (15). The level of macronutrient adequacy was categorized based on the Ministry of Health criteria (1996) cited in Nurohmi and Amalia (16) as follows: severe deficit (<70% of requirement), moderate deficit (70–79% of requirement), mild deficit (80–89% of requirement), normal (90–119% of requirement), and excessive (≥120% of requirement). The variables were dichotomized to provide statistical robustness and solve the problem of tiny anticipated frequencies in multiple cells. (1) Suboptimal (including all deficit and excessive categories) and (2) Optimal (90–119% sufficiency) were the two categories used to simplify intake of nutrients levels. Micronutrient intake were already two categories: deficient (<77%) and adequate (≥77%) (17).

Data analysis involved both descriptive and inferential statistics. Descriptive analysis was applied to determine the distribution of baseline characteristics and the profiles of childhood nutrient intake levels, presented as frequencies and percentages. Inferential analysis was analyzed using the Chi-square test. However, for 2x2 tables where the expected cell frequency was less than five, Fisher’s Exact Test was applied to ensure statistical validity, as the variables under evaluation were dichotomic categorical. Microsoft Excel and SPSS version 26.0 were utilized to execute all statistical analyses.

CODE OF HEALTH ETHICS

This study received formal ethical clearance (Approval No. 0788/HRECC.FODM/VII/2024) granted by the Health Research Ethics Committee of the Faculty of Dental Medicine, Universitas Airlangga.

RESULTS

This study evaluated 80 primary school children (aged 9–11 years) in Kediri City to establish a comprehensive profile of their nutritional intake. Data were obtained using structured questionnaires, 2x24-hour dietary recalls, and direct anthropometric measurements to determine nutritional status. The baseline characteristics of the subjects are presented in Table 1.

Table 1. Baseline Characteristics of the Subjects (N = 80)

Variable	n	%
Gender		
Male	45	56.2
Female	35	43.8
Age (years old)		
9	11	13.8
10	36	45.0
11	33	41.2
Nutritional Status (BAZ)		
Abnormal	41	51.2
Thinness	1	2.4
Overweight	12	29.3
Obesity	28	68.3
Normal	39	48.8

The baseline characteristics and nutritional status profiles involved 80 primary school subjects within an age range of 9 to 11 years in Kediri City. The majority of the subjects were male (56.2%), with the most prominent age cohort concentrated at 10 years old (45.0%). Based on anthropometric measurements utilizing BMI-for-age Z-scores (BAZ), nearly half of the subjects (48.8%) exhibited a normal weight status.

https://doi.org/10.56303/jian.v1i2.1604

Table 2. Profile of Nutrient Intake Adequacy Levels

Nutrient Intake Level (%)	N = 80	
	n	%
Energy		
Suboptimal	78	97.5
Optimal	2	2.5
Protein		
Suboptimal	58	72.5
Optimal	22	27.5
Fat		
Suboptimal	64	80.0
Optimal	16	20.0
Carbohydrate		
Suboptimal	78	97.5
Optimal	2	2.5
Iron		
Deficient	72	90.0
Adequate	8	10.0
Calcium		
Deficient	80	100.0
Adequate	0	0.0
Zinc		
Deficient	76	95.0
Adequate	4	5.0
Phosphorus		
Deficient	75	93.8
Adequate	5	6.3

The nutritional intake data revealed a concerning landscape, with a vast majority of the subjects experiencing severe dietary deficits despite the high rates of obesity. Within the macronutrient categories, suboptimal intake were dominated all of them. Suboptimal nutrient intake among the children encompasses conditions of both intake deficits (severe, moderate, and mild) and nutritional surpluses (excessive intake). 97.5% of subjects suffered from suboptimal energy and carbohydrate intake, 80.0% of fat intake, and 72.5% of protein intake. Micronutrient intake profiles demonstrated a far more massive scale of deficiency. Remarkably, 100% of the subjects exhibited a calcium deficiency, while more than 90% of subjects were deficient in iron (90.0%), zinc (95.0%), and phosphorus (93.8%). Overall, calcium, energy, and carbohydrates represented the nutritional components with the highest percentages of suboptimal intake among the children.

Table 3. Association Between Nutrient Intake Levels and Nutritional Status (BAZ)

Nutrient Intake Level (%)	Nutritional Status				p-value[a]
	Abnormal		Normal		
	n	%	n	%	
Energy					
Suboptimal	40	51.3	38	48.7	0.741
Optimal	1	50.0	1	50.0	
Protein					
Suboptimal	34	58.6	24	41.4	0.029*
Optimal	7	31.8	15	68.2	
Fat					
Suboptimal	34	53.1	30	46.9	0.348
Optimal	7	43.8	9	56.3	

https://doi.org/10.56303/jian.v1i2.1604

Nutrient Intake Level (%)	Nutritional Status				p-value[a]
	Abnormal		Normal		
	n	%	n	%	
Carbohydrate					
Suboptimal	40	51.3	38	48.7	0.741
Optimal	1	50.0	1	50.0	
Iron					
Deficient	35	48.6	37	51.4	0.148
Adequate	6	75.0	2	25.0	
Calcium					
Deficient	41	51.2	39	48.8	1.000
Adequate	0	0.0	0	0.0	
Zinc					
Deficient	40	52.6	36	47.4	0.289
Adequate	1	25.0	3	75.0	
Phosphorus					
Deficient	39	52.0	36	48.0	0.476
Adequate	2	40.0	3	60.0	

[a]Fisher’s Exact Test; Data presented as n (%) of total sample; *significant if p-value ≤ 0.05.

Bivariate inferential analysis using Fisher’s Exact Test was conducted to evaluate the associations between specific nutrient intake adequacy levels and the children's anthropometric status. The statistical results revealed a significant relationship between nutritional status (BAZ) and the intake levels of protein ($p = 0.029$). This demonstrates that although overall intakes were uniformly deficient across all nutritional status categories, the protein intake was associated with the children's anthropometric profiles. Conversely, no statistically significant associations were found between BAZ status and another macro-micronutrient intake.

DISCUSSION

The findings confirm a critical public health paradox among primary school children in Kediri City, where a high prevalence of abnormal nutritional status (51.2%, dominated by 29.3% overweight and 68.3% obesity) coexists with massive macronutrient suboptimality and micronutrient deficiencies. This phenomenon illustrates the clinical phenotype of the individual double burden of malnutrition (18) or cellular-level malnutrition (hidden hunger) (19). While primary school-based studies across other developing countries report undernutrition as the more prevalent indicator (20), our findings align with recent trends reflecting a rapid nutrition transition where overnutrition has become the more prevalent burden (21,22).

This paradox is largely driven by modern school food environments and broader socio-behavioral shifts. Based on the portrait of food recall, our observations indicate that most children consumed minimal, unvaried, and highly processed foods, frequently skipping breakfast. School-sourced snacks are energy-dense but nutrient-poor, characterized by excessive sugars, salt, and lipids at the expense of necessary protein, fiber, and micronutrients (23). Sociologically, as the children transition into late childhood and pre-adolescence, increased peer socialization and independent pocket money (24,25) spending further amplify preferences for low-nutrient, deep-fried snacks and sugar-sweetened beverages.

Regular consumption of unhealthy options, such as foods high in saturated fats, sugar-sweetened beverages, red meat, and sodium-dense processed meats, is strongly linked to an elevated risk of cardiovascular disease (26). Furthermore, the immediate school food environment plays a pivotal role; the availability of school-adjacent snack vendors heavily drives childhood consumption patterns toward ultra-processed options high in carbohydrates and fats (23). Studies indicate that deep-fried snacks are consumed in significantly higher frequencies by children with elevated anthropometric statuses (overweight and obesity) compared to their normal-weight or thin peers (27). Peer influence heavily shapes children's evolving food preferences and peer-driven eating habits, requiring parents to realistically manage these typical behaviors to foster positive dietary choices (3).

https://doi.org/10.56303/jian.v1i2.1604

Consequently, obesity-related malnutrition manifests as a distinct clinical phenotype, where poor-quality diets rich in saturated fats and refined carbohydrates induce systemic inflammation, gut dysbiosis, and key micronutrient deficiencies despite a chronic state of energy surplus (19). Moreover, poor dietary quality is strongly linked to an elevated risk of tracking non-communicable diseases into later life, including cardiovascular diseases, type 2 diabetes mellitus, and chronic adiposity (28).

The only statistical analysis associations with nutritional status (BAZ) was observed for protein intake levels ($p = 0.029$). Ensuring sufficient protein consumption is crucial for facilitating proper childhood development and lifelong health, requiring personalized nutritional approaches that adapt to the evolving demands of growing children (29). These findings align with recent reviews regarding the dietary patterns of school-age children and early adolescents, which indicate that children regularly consume less protein, fruits, and vegetables than recommended, while maintaining a disproportionately high intake of refined carbohydrates, soft drinks, and confectionery sweets (30). For those under the age of nineteen, adequate consumption of high-quality, animal-based protein is crucial to promote optimal linear growth, cellular development, and lean body mass accumulation during childhood (31,32).

In contrast, no significant associations were observed fot other macronutrient and micronutrient. If energy and carbohydrate intakes remain chronically below daily recommendations, the body compensates by catabolizing protein pathways for energy production (3). This metabolic shift not only threatens physical growth but also compromises cognitive efficiency and concentration during the learning process at school (33), particularly as the brain accounts for approximately 30% of total energy expenditure as children approach 12 years of age (1).

Consequently, school-age children in Indonesia continue to face persistent micronutrient deficiencies (34). The micronutrient intake landscape observed in this study is particularly alarming. Calcium deficiency reached 100%, and phosphorus reached 93.8% among the subjects. Physiologically, however, these widespread micronutrient gaps represent a severe developmental concern. Middle childhood represents a critical window for bone mineral content (BMC) accretion (35), given that over 80% of adult skeletal mass is established before the conclusion of the school-age years (1). Calcium is the primary nutrient of bone mineral density (36), whereas phosphorus balance is highly sensitive and directly linked to linear growth trajectories (37). The 100% calcium deficiency observed in our study subject has the potential to limit the achievement of peak bone mass, thereby escalating the long-term risk of osteoporosis and fractures in adulthood (1). Similarly, widespread deficits in iron (90.0%), and zinc (95.0%) threaten immune function (38), epiphyseal growth plate activity (38), neurological maturation, and neurotransmitter synthesis (39).

This lack of significance is primarily driven by the homogeneity of suboptimal nutrient intake across all anthropometric groups. Almost all children suffered from a suboptimal energy regardless of whether they were classified as abnormal, or normal nutritional status. For example, energy intake was suboptimal in 97.5% of childrens, while calcium deficiency reached 100% ($p = 1.000$) in a bivariate model. Therefore, calcium failed statistically despite its crucial physiological role in bone matrix mineralization, synergistically with phosphorus (35,40).

The study's limitations include the use of purposive sampling, which means it can only give an overview of the relationship rather than demonstrate causal relationships. In addition, even though the children were accompanied by their mothers for mutual validation during the two 24-hour food recall interviews, the 24-hour recall method may introduce consumption bias when respondents remember what they ingested, potentially leading to over- or under-reporting. Furthermore, since children frequently participate in activities outside the house, confounding variables like physical activity levels were not measured.

CONCLUSION

School-age children in Kediri City exhibit a paradoxical individual double burden of malnutrition, where high obesity rates coexist with near-universal nutrient deficits, most notably a 100% calcium deficiency. Statistical analysis found an association between nutritional status (BAZ) and the intake levels of protein. This emphasizes that dietary intake is associated with a child's critical developmental periods. To address these systemic gaps, specific policy shifts are required, such as regulating school-adjacent snack vendors to limit nutrient-poor foods and integrating nutritional literacy directly into the school curriculum. Consequently, targeted nutritional education interventions are urgently required, specifically those leveraging multi-layered socio-ecological support

https://doi.org/10.56303/jian.v1i2.1604

systems (encompassing families, peers, and school environments) to sustainably improve childhood dietary quality and nutritional status. Surveillance of nutritional status must expand beyond the under-five period and be rigorously maintained throughout the school-age years to guarantee that children achieve their full biological potential and secure long-term health outcomes.

FUNDING

This research received no external funding.

ACKNOWLEDGMENTS

The authors would like to thank the Education Office of Kediri City, East Java, the participating schools, all respondents, and all parties who assisted in the data collection and completion of this research.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Saavedra JM, Prentice AM. Nutrition in school-age children: a rationale for revisiting priorities. Nutr Rev. 2023;81(7):823–43. doi:10.1093/nutrit/nuac089
2. Yu Q, Hodgdon EA, Kryza-Lacombe M, Osuna L, Bozzetto LE, Ciro D, et al. Roads Diverged: Developmental Trajectories of Irritability From Toddlerhood Through Adolescence. J Am Acad Child Adolesc Psychiatry. 2023;62(4):457–71. doi:10.1016/j.jaac.2022.07.849
3. Raymond JL, Morrow K. Krause and Mahan’s Food and The Nutrition Care Process. 15th ed. St. Louis: Elsevier; 2021.
4. Critch JN. School nutrition: Support for providing healthy food and beverage choices in schools. Paediatr Child Health. 2020;25(1):33–46. doi:10.1093/pch/pxz102
5. World Health Organization. WHO Global Anaemia Estimates, 2021 Edition. Geneva: World Health Organization; 2021.
6. Kementerian Kesehatan Republik Indonesia. Survei Kesehatan Indonesia (SKI) dalam Angka 2023. Jakarta: Kementerian Kesehatan Republik Indonesia; 2023.
7. Gutema BT, Sorrie MB, Megersa ND, Yesera GE, Yeshitila YG, Pauwels NS, et al. Effects of iron supplementation on cognitive development in school-age children: systematic review and meta-analysis. PLoS One. 2023;18(6):e0287703. doi:10.1371/journal.pone.0287703
8. World Health Organization. The double burden of malnutrition: policy brief. Geneva: World Health Organization; 2017.
9. World Health Organization. The double burden of malnutrition: priority actions on ending childhood obesity. New Delhi: World Health Organization, Regional Office for South-East Asia; 2020.
10. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet. 2020;395(10217):65–74. doi:10.1016/S0140-6736(19)32497-3
11. Badan Penelitian dan Pengembangan Kesehatan. Laporan Riskesdas Provinsi Jawa Timur 2018. Jakarta: Lembaga Penerbit Badan Penelitian dan Pengembangan Kesehatan; 2019.
12. Conner TS, Brookie KL, Carr AC, Mainvil LA, Vissers MCM. Let them eat fruit! The effect of fruit and vegetable consumption on psychological well-being in young adults: A randomized controlled trial. PLoS One. 2017;12(2):e0171206. doi:10.1371/journal.pone.0171206
13. Risti KN, Pamungkasari EP, Suminah. Nutrition knowledge and healthy food choices after participating in online nutrition education in overweight adolescents. In: Proceedings of the International Conference on Health and Medical Sciences (AHMS 2020). Paris: Atlantis Press; 2021. p. 46–9.
14. Kementerian Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2020 tentang Standar Antropometri Anak. Jakarta: Kementerian Kesehatan Republik Indonesia; 2020.
15. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: The National Academies Press; 2005.

https://doi.org/10.56303/jian.v1i2.1604

16. Nurohmi S, Amalia L. Pengetahuan gizi, aktivitas fisik, dan tingkat kecukupan gizi aktivis Badan Eksekutif Mahasiswa (BEM) IPB. J Gizi dan Pangan. 2012;7(3):151-156. doi:10.25182/jgp.2012.7.3.151-156
17. Gibson RS. Principles of Nutrition assessment. 2nd ed. New York: Oxford University Press; 2005.
18. Kiosia A, Dagbasi A, Berkley JA, Wilding JPH, Prendergast AJ, Li J V, et al. The double burden of malnutrition in individuals: Identifying key challenges and re-thinking research focus. Nutr Bull. 2024;49(2):132–45. doi:10.1111/nbu.12670
19. Dargenio V, Sgarro N, La Grasta G, Begucci M, Castellaneta S, Dargenio C, et al. Hidden Hunger in Pediatric Obesity: Redefining Malnutrition Through Macronutrient Quality and Micronutrient Deficiency. Nutrients. 2025;17(22):3601. doi:10.3390/nu17223601
20. Umeokonkwo AA, Ibekwe MU, Umeokonkwo CD, Okike CO, Ezeanosike OB, Ibe BC. Nutritional status of school age children in Abakaliki metropolis, Ebonyi State, Nigeria. BMC Pediatr. 2020;20(1):114. doi:10.1186/s12887-020-1994-5
21. Wrottesley SV, Mates E, Brennan E, Bijalwan V, Menezes R, Ray S, et al. Nutritional status of school-age children and adolescents in low- and middle-income countries across seven global regions: a synthesis of scoping reviews. Public Health Nutr. 2023;26(1):63–95. doi:10.1017/S1368980022000350
22. Sunguya BF, Ong KI, Dhakal S, Mlunde LB, Shibanuma A, Yasuoka J, et al. Strong nutrition governance is a key to addressing nutrition transition in low and middle-income countries: review of countries' nutrition policies. Nutr J. 2014;13(1):65. doi:10.1186/1475-2891-13-65
23. Rembet TG, Nugroho KPA, Mangalik G. Gambaran konsumsi gula, garam dan lemak (minyak) pada anak sekolah. J Ilmu Kesehat Masy. 2021;10(4):230–7. doi:10.33221/jikm.v10i04.877
24. Kementerian Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 41 Tahun 2014 tentang Pedoman Gizi Seimbang. Jakarta: Kementerian Kesehatan Republik Indonesia; 2014.
25. Ragelienė T, Grønhøj A. The influence of peers′ and siblings′ on children's and adolescents′ healthy eating behavior. A systematic literature review. Appetite. 2020;148:104592. doi:10.1016/j.appet.2020.104592
26. Chen W, Zhang S, Hu X, Chen F, Li D. A Review of Healthy Dietary Choices for Cardiovascular Disease: From Individual Nutrients and Foods to Dietary Patterns. Nutrients. 2023;15(23):4898. doi:10.3390/nu15234898
27. Anggiruling DO, Ekayanti I, Khomsan A. Analisis faktor pemilihan jajanan, kontribusi gizi dan status gizi siswa sekolah dasar. Media Kesehat Masy Indones. 2019;15(1):81. doi:10.30597/mkmi.v15i1.5914
28. Koivuniemi E, Nuutinen O, Riskumäki M, Vahlberg T, Laitinen K. Development of a stand-alone index for the assessment of diet quality in elementary school-aged children. Public Health Nutr. 2021;24(17):5629–40. doi:10.1017/S1368980021003657
29. Soliman N, Soliman A, Alyafei F, ElSiddig S, Alaaraj N, Hamed N, et al. The varied effects of protein intake during infancy, childhood, and adolescence: Associations with growth metrics, body composition, and pubertal development timelines. World J Adv Res Rev. 2024;21(3):657–66. doi:10.30574/wjarr.2024.21.3.0769
30. Khan DSA, Das JK, Zareen S, Lassi ZS, Salman A, Raashid M, et al. Nutritional Status and Dietary Intake of School-Age Children and Early Adolescents: Systematic Review in a Developing Country and Lessons for the Global Perspective. Front Nutr. 2022;8:739447. doi:10.3389/fnut.2021.739447/full
31. Wu G. Dietary protein intake and human health. Food Funct. 2016;7(3):1251–65. doi:10.1039/C5FO01530H
32. Jannati N, Mahmoodi MR, Azadbakht L. Protein and fat intake impact on growth of primary school girls in Kerman, Iran. Sci Rep. 2024;14(1):15288. doi:10.1038/s41598-024-66001-4
33. Wote AYV, Sasingan M, Kusumawati MMPN. Correlation of breakfast with learning concentration in fourth grade elementary school. J Psychol Instr. 2023;6(3):122–7. doi:10.23887/jpai.v6i3.52275
34. Ernawati F, Efriwati, Nurjanah N, Aji GK, Hapsari Tjandrarini D, Widodo Y, et al. Micronutrients and Nutrition Status of School-Aged Children in Indonesia. J Nutr Metab. 2023;2023(1):4610038. doi:10.1155/2023/4610038
35. Abrams SA. Bone Health in School Age Children: Effects of Nutritional Intake on Outcomes. Front Nutr. 2021;8:773425. doi:10.3389/fnut.2021.773425

https://doi.org/10.56303/jian.v1i2.1604

36. Soliman A, Alaaraj N, Hamed N, Alyafei F, Ahmed S, Shaat M, et al. Nutritional interventions during adolescence and their possible effects. Acta Biomed. 2022;93(1):1–14. doi:10.23750/abm.v93i1.12789
37. Ariani, Krisni S, Yoella HP. Association of vitamin D and phosphor levels with growth retardation in children with chronic kidney disease. Pediatr Sci J. 2022;3(1):13–6. doi:10.51559/pedscij.v3i1.34
38. Inzaghi E, Pampanini V, Deodati A, Cianfarani S. The Effects of Nutrition on Linear Growth. Nutrients. 2022;14(9):1752. doi:10.3390/nu14091752
39. Abd El-Salam GMS, Abd El-Gaffar ES, Abd El-Samad HM. Effects of iron-deficiency anemia on auditory function in school-aged children. J Med Sci Res. 2018;1(4):239. doi:10.4103/JMISR.JMISR_71_18
40. Pons-Belda OD, Alonso-Álvarez MA, González-Rodríguez JD, Mantecón-Fernández L, Santos-Rodríguez F. Mineral Metabolism in Children: Interrelation between Vitamin D and FGF23. Int J Mol Sci. 2023;24(7):6661. doi:10.3390/ijms24076661

https://doi.org/10.56303/jian.v1i2.1604