BIO Web of Conferences **193**, 00040 (2025) https://doi.org/10.1051/bioconf/202519300040
ICOPH-TCD 2025

Micronutrient Status of Children Aged 7-59 Months Old with Overweight/Obese in Indonesia: Basic Health Research 2018

Aya Yuriestia Arifin[1*], *Rimbawan* Rimbawan[2], *Hadi* Riyadi[2], Fitrah *Ernawati*[1], *Efriwati* Efriwati [1], *Nunung* Nurjanah[1], *Elisa Diana* Julianti[1], *Fifi* Retiaty[1], and *Dian* Sundari[1]

[1]Research Center for Public Health and Nutrition, National Research and Innovation Agency of Indonesia, Bogor West Java, 16915, Indonesia
[2]Department of Community Nutrition, IPB University, Bogor, West Java, 16680, Indonesia

Abstract. Numerous studies have highlighted the rising prevalence of overweight and obesity. In recent years, these conditions have also been increasingly observed in children. One interesting aspect to explore is the micronutrient profile of overweight and obese children, whether they generally fall within sufficient ranges, excessive, or conversely, show signs of deficiency. This study aims to examine the micronutrient status, namely serum vitamin A, 25(OH)D, zinc, iron, and calcium in children under five years old with an overweight/obese nutritional status (WHZ > +2SD). The design of the study was cross-sectional using secondary data from Riskesdas 2018 and the following study in 2021. Serum was analysed for retinol, 25(OH)D, zinc, ferritin, and calcium levels, then categorized into vitamin A, vitamin D, zinc, iron, and calcium status, respectively. The subjects of the study were 539 children aged 7-59 months. Data analysis included bivariate and multivariate regression. The results showed 7.9% were overweight/obese. No significant difference was found for all micronutrient levels between overweight/obese and those with non-overweight status. Children with insufficient levels of vitamin D were significantly associated with overweight/obesity (p=0.014, aOR 4.516, 95% CI: 1.358–15.010). Furthermore, zinc and iron overall showed the highest deficiency number, recorded at 213 and 187 subjects respectively. Interestingly, about 10% of the children with these deficiencies were still categorized as overweight/obese.

1 Introduction

Indonesia is currently experiencing a triple burden of malnutrition, characterized by the coexistence of undernutrition, overnutrition, and micronutrient deficiencies (MNDs) within the population. While national health strategies have made significant efforts to address undernutrition and the increasing prevalence of overweight and obesity, an emerging concern is the deficiency of essential micronutrients, which is now gaining attention in both clinical and public health contexts [1]. MNDs, unlike macronutrient imbalances, are particularly challenging to detect. These deficiencies typically arise from inadequate dietary intake of essential vitamins and minerals, leading to subclinical yet impactful health outcomes [2]. In children, MNDs during critical periods of growth can have direct and lasting effects on

* Corresponding ayarifin@gmail.com

physical development, cognitive function, immunity, and overall survival. The consequences of such deficiencies are far-reaching, potentially increasing disease susceptibility, impairing school performance, and limiting future productivity and quality of life [3,4].

MNDs are commonly observed in children with undernutrition. However, recent studies have begun to highlight the occurrence of MNDs in children who are overweight or obese. Despite excessive caloric intake, children with obesity often exhibit significant MNDs. These nutritional inadequacies, often masked by excess weight, may contribute to metabolic disturbances and adverse health outcomes. A comprehensive narrative review highlighted that deficiencies in iron, vitamins A, B, C, D, and E, folic acid, zinc, and copper are prevalent among this group. These deficiencies may contribute to obesity-related metabolic comorbidities, underscoring the complexity of malnutrition beyond mere caloric excess [5]. Deficiencies in iron, zinc, copper, and vitamin B impair enzymatic pathways of carbohydrate and lipid metabolism, reducing the efficiency of energy utilization and promoting fat accumulation [6]. Low vitamin D and vitamin A influence adipogenesis, insulin sensitivity, and inflammatory pathways, thereby aggravating obesity-related dysregulation [5]. Vitamin C and vitamin E deficiencies further enhance oxidative stress and chronic inflammation, which are commonly associated with obesity. Collectively, this nutrient-energy imbalance fosters a metabolic milieu in which surplus caloric intake more readily translates into adiposity and obesity-related comorbidities [5].

The mechanisms linking obesity to MNDs are multifaceted. Increased adiposity can lead to sequestration of fat-soluble vitamins, reducing their bioavailability. Additionally, chronic low-grade inflammation associated with obesity may impair the absorption and utilization of essential nutrients [7]. Moreover, dietary patterns prevalent among children with obesity often emphasize energy-dense, nutrient-poor foods, further exacerbating the risk of MNDs [8]. This dietary imbalance, coupled with physiological changes in nutrient metabolism, creates a paradox where excessive caloric intake coexists with inadequate micronutrient status [7].

Given the importance of adequate micronutrient intake during periods of rapid growth and development, understanding the micronutrient profiles of overweight and obese children is crucial. This includes determining whether their levels of micronutrients fall within sufficient ranges, are excessive, or, conversely, show signs of deficiency. Investigating this relationship may help guide more comprehensive and effective nutritional interventions for pediatric populations affected by excess body weight.

2 Methods

This study employed a cross-sectional design using secondary data from the 2021 study on Micronutrient Status of Children Under Five and School-Age Children. The study involved a total of 3,006 subjects, of which 539 were children aged 7-59 months. The study was approved by the Ethics Committee of the National Institute of Health Research and Development (Ethical Approval No. LB.02.01/2/KE/658/2021, dated October 26, 2021). The data analysed focused on serum levels of retinol, 25(OH)D, zinc, ferritin, and total calcium obtained from the biorepository of serum collected during the 2018 Basic Health Research (Riskesdas).

The serum had been preserved for three years at -80°C in an ultralow temperature freezer at the formerly National Institute of Health Research and Development (Balitbangkes), Jakarta. Laboratory measurements were conducted at the Nutrition Laboratory of the Biomedical and Basic Health Technology Research and Development Center, located on Jl. Dr. Sumeru No. 63, Bogor. Serum retinol concentration was measured using High-Performance Liquid Chromatography (HPLC), serum zinc by Atomic Absorption Spectroscopy (AAS), serum 25(OH)D and ferritin by Enzyme-Linked Immunosorbent Assay

(ELISA), and serum calcium by the enzymatic method. Deficiency status was determined based on established cut-offs: retinol < 0.70 µmol/L for vitamin A (FAO/WHO, 2004), serum 25(OH)D < 12 ng/mL for vitamin D (IOM, 2011), and zinc < 9.9 µmol/L for children. Ferritin levels were adjusted for inflammation using C-reactive protein (CRP > 5 mg/L) with a correction factor of 0.65. Iron deficiency was defined as serum ferritin < 12 µg/L, according to WHO standards. Serum calcium concentration was categorized into calcium status based on its threshold levels: 9.0–10.4 mg/dL for the sufficient category, and < 9.0 mg/dL for the deficiency category [1].

Demography data—including age, sex, and anthropometry—were sourced from the 2018 Basic Health Research Survey (Riskesdas). The study population included children under five years of age (7–59 months) who had complete sample identification data and were matched to Riskesdas 2018 data, totalling 539 subjects. Determination of children's nutritional status was based on the Weight-for-height z-score (WHZ score) according to their respective ages in the year 2018. Overweight/obese was defined by WHZ score > +2 SD, while those with a WHZ score equal to or lower than +2 SD were categorized as not overweight [9].

Data processing and analysis were performed using Microsoft Excel 2010 and SPSS (Statistical Package for the Social Sciences) version 25.0 for Windows. The analysis included chi-square cross-tabulation to explore associations between dependent and independent variables. A t-test was used to compare micronutrient levels across different nutritional status groups. Furthermore, multivariate regression analysis was conducted to determine the influence of micronutrient status on overweight/obesity in children. Results are expressed as mean with standard deviations for continuous variables or as frequencies with percentages (n, %) for categorical variables, with a significance level $p < 0.05$.

3 Results And Discussion

3.1 Study Population

Overweight and obesity status in children was determined based on weight-for-height z-scores (WHZ), where a WHZ greater than +2 SD indicated overweight or obesity. Refer to the WHO Child Growth Standards (2006) as it reflects excess body weight relative to healthy growth reference and allows cross-country comparability. Children with WHZ scores ≤ +2 SD were categorized as non-overweight. A detailed description of the characteristics of both groups is presented in Table 1. The majority of overweight/obese children were within the age group of 25–59 months, accounting for 81.4% of the overweight/obese category. Boys had a higher prevalence of overweight/obese compared to girls.

Additionally, of 79 children (14.6%) who were recorded as having a birth weight over 3,500 grams, 9.3% of them were classified as overweight/obese. The mean BMI-for-age showed a gradual increase from the age of 7–12 months up to five years. However, statistical analysis revealed no significant associations between age, gender, or birth weight and the weight-for-height z-score (WHZ) nutritional status among children aged 7 to 59 months in this study population.

Table 1. Proportion of overweight/obese children (n(%)) and profile of BMI-for-age (Mean±SD), characterized by age group, gender, and birth weight

Variable	WHZ		Total N=539	p-Value	BMI-for-age (kg/m^2)
	Overweight /obese, n=43	Non-Overweight, n=496			

Age group (month)					
7-12	1(2.3)	31(6.3)	32(5.9)	0.579	16.89±2.42
13-24	7(16.3)	77(15.5)	84(15.6)		15.95±2.48
25-59	35(81.4)	388(78.2)	423(78.5)		15.67±2.92
Gender					
Boys	24(55.8)	280 (56.5)	304(56.4)	0.936	15.76±2.26
Girls	19(44.2)	216(43.5)	235(43.6)		15.82±3.45
Birth weight (gram)					
<2500	4(9.3)	23(4.6)	27(5.1)	0.267	16.74±5.66
2500-3500	35(81.4)	398(80.3)	433(80.3)		15.71±2.69
>3500	4(9.3)	75(15.1)	79(14.6)		15.89±2.06

WHZ= Weight-for-height z-score; BMI-for-age=Body Mass Index-for-age.

3.2 Micronutrient Profile in Overweight/Obese Children

The mean concentrations of micronutrients in overweight/obese and non-overweight children are presented in Table 2. All mean serum micronutrient concentrations were within normal ranges and above deficiency thresholds. Serum 25(OH)D levels ranged between 66 to 67 ng/mL, well above the optimal cut-off of 20 ng/mL, which has been associated with lower risks of bone fragility, secondary hyperparathyroidism, and fractures [10]. Serum retinol levels were also above the deficiency cut-off of 0.70 µmol/L in both groups. Mean serum zinc levels were 11.04 µmol/L in overweight/obese children and 11.39 µmol/L in non-overweight children, both exceeding the deficiency threshold of 9.9 µmol/L. Inflammation-adjusted ferritin levels mean 25.84 µg/L in overweight/obese children and 28.07 µg/L in those non-overweight. The large standard deviation observed in ferritin concentrations was likely due to natural fluctuations in iron stores from birth through early childhood. Elevated ferritin levels above 1000 µg/L with CRP <40 mg/L might have indicated ongoing inflammation, whereas concurrent increases in both ferritin and CRP (>40 mg/L) could have suggested hyperinflammatory conditions or sepsis [11]. Serum calcium levels in both groups remained within the normal physiological range of 9.0–10.4 mg/dL, regulated by homeostatic mechanisms involving parathyroid hormone (PTH), 1,25-dihydroxyvitamin D [$1,25(OH)_2D$], and calcitonin [12].

Table 2. Micronutrient level (Mean±SD) of overweight/obese (n=43) and not overweight (n=496) children

Variable	**WHZ**		**p-Value**	**95% CI**
	Overweight/ obese	**Non-Overweight**		
Retinol (µmol/L)	1.18±0.36	1.11±0.33	0.209	-0.19 – 0.04
25(OH)D (ng/mL)	66.43±33.93	67.56±28.24	0.803	-7.83 – 10.11
Zinc (µmol/L)	11.04±3.20	11.39±3.50	0.502	-0.68 – 1.37
Ferritin (µg/L)	25.84±29.57	28.07±26.88	0.634	-7.15 – 11.62
Calcium (mg/dL)	9.96±0.67	10.01±1.13	0.722	-0.18 – 0.27

WHZ= Weight-for-height z-score

The results indicated that overweight/obese children had slightly lower micronutrient levels compared to their non-overweight counterparts, although these levels were still within the sufficient range. This finding highlights a nutritional paradox commonly observed in childhood obesity, despite excessive caloric intake, many overweight children do not receive adequate levels of essential vitamins and minerals. Diets high in energy-dense, nutrient-poor foods, such as processed snacks and sugary beverages, contribute to this imbalance by providing surplus calories but lacking key micronutrients like iron, vitamin D, and zinc. While these lower micronutrient levels may not immediately fall below the thresholds, they can still pose risks for long-term health, potentially affecting immune function, bone development, and cognitive performance during critical growth periods [3]. Additionally, obesity-related inflammation and metabolic alterations may further impair nutrient absorption and utilization [7].

Micronutrient deficiencies are suspected to be associated with the occurrence of overweight and obesity in children under five years of age. In this study, 515 children were found to have sufficient levels of vitamin D, with 37 of them representing over 7%, classified as overweight/obese (Table 3). This finding supports the hypothesis of a potential correlation between vitamin D status and overweight/obesity. However, statistical analysis revealed that only children with insufficient levels of vitamin D showed a significant positive association with overweight/obesity ($p = 0.014$), with an adjusted odds ratio (aOR) of 4.516 (95% CI: 1.358–15.010), indicating a higher likelihood of developing overweight/obesity. Meanwhile, deficiencies in other micronutrients did not show similar associations.

The relationship between vitamin D status and obesity has been widely investigated over the years. As a fat-soluble vitamin, vitamin D tends to appear in lower serum concentrations among individuals with overweight or obesity. This is partly due to its increased sequestration in adipose tissue, especially in individuals with low mobility or limited sun exposure. A meta-analysis conducted by Fiamenghi and de Mello (2020) found that children and adolescents with obesity are at greater risk of vitamin D deficiency [10]. Low vitamin D levels may worsen the metabolic profile of obese youth, as circulating 25(OH)D is positively correlated with insulin sensitivity. This suggests that children with obesity and poor vitamin D status may be more vulnerable to impaired glucose metabolism [10]. Supporting this, a study by Zou et al. (2022) involving 2818 children and adolescents in Zhejiang Province, China, revealed significant differences in serum 25(OH)D3 concentrations based on nutritional status. Interestingly, serum 25(OH)D3 levels were higher among those classified as obese [13].

Table 3. Micronutrient status effect on overweight/obese children after adjusted with age and gender

Variable	WHZ		aOR (95% CI)	p-Value
	Overweight/ obese	Non-Overweight		
Vitamin A				
Sufficient	40 (93.1)	456 (91.9)	1	
Deficiency	3 (6.9)	40 (8.1)	0.877 (0.259 – 2.971)	0.833
Vitamin D				
Sufficient	37 (86.1)	478 (96.4)	1	
Insufficient	4 (9.3)	11 (2.2)	4.516 (1.358 – 15.010)	0.014*
Deficiency	1 (2.3)	1 (0.2)	12.311 (0.741 – 204.488)	0.080

Toxic	1 (2.3)	6 (1.2)	2.353 (0.271 – 20.451)	0.438
Zinc				
Sufficient	24 (55.8)	302 (60.9)	1	
Deficiency	19 (44.2)	194 (39.1)	1.227 (0.654 – 2.301)	0.524
Iron				
Sufficient	24 (55.8)	328 (66.1)	1	
Deficiency	19 (44.2)	168 (33.9)	1.576 (0.837 – 2.967)	0.159
Calcium				
Sufficient	39 (90.7)	455 (91.7)	1	
Deficiency	4 (9.3)	41 (8.3)	1.097 (0.372 – 3.239)	0.867

**Significant at $p<0.05$; WHZ= Weight-for-height z-score*

Although the statistical analysis in this study indicated that vitamin A status was not significantly associated with overweight or obesity, several previous studies have found otherwise. Zou et al. (2022) suggested that vitamin A may be closely linked to overweight and obesity. In a study involving 2818 children and adolescents as part of the China National Nutrition and Health Survey 2016–2017, the average BMI was found to be 18.7 kg/m^2, with a serum retinol concentration of 2.8 mg/mL. The study also reported that higher vitamin A levels were associated with higher BMI values. These findings suggest that vitamin A status may play a role in the development of obesity, particularly among children and adolescents, although the underlying biological mechanisms still require further investigation [13].

Calcium also plays significant roles in the context of obesity and child health, as lower calcium levels are associated with greater fat mass. A study conducted in Spain involving 78 children with chronic illnesses found an inverse relationship between serum calcium levels and nearly all anthropometric and body composition parameters examined, including height-for-age z-scores (HAZ), BMI, upper wrist circumference, and hip circumference. These findings suggest that lower calcium levels are associated with greater body size and adiposity. Moreover, in children with overweight or obesity, calcium has been identified as a potential risk factor for elevated blood pressure [12].

The highest prevalence of deficiency among the overweight/obese group was observed in zinc and iron. Specifically, of the 43 children identified as overweight/obese, 44.2% were deficient in one or both of these micronutrients. In other words, approximately 10% of children who had these deficiencies were categorized as overweight/obese (Table 3). This is particularly concerning given the essential physiological roles of both zinc and iron in immune function, cognitive development, and metabolic regulation [14]. Zinc plays a key role in cellular growth, appetite control, and insulin sensitivity [6], while iron is crucial for oxygen transport and neurodevelopment [15]. Deficiencies in these nutrients among overweight children may exacerbate the health risks already posed by excess body fat, such as inflammation, insulin resistance, and delayed physical or cognitive development [3]. A systematic review and meta-analysis further corroborated these findings, revealing that overnutrition (overweight and obesity) increases the odds of iron deficiency in children. Interestingly, the odds appeared higher in children with obesity compared to those with overweight, suggesting a nuanced relationship between body weight and micronutrient status [7].

These findings emphasize the need to shift from a narrow focus on caloric intake in obesity interventions toward a more comprehensive approach that also addresses diet quality and micronutrient sufficiency [1]. It is essential for healthcare providers and public health policies to recognize that children with obesity are not immune to undernutrition and may, in fact, face a triple burden of malnutrition that requires targeted nutritional assessment and intervention [10]. A concerning trend of MNDs accompanies the rising prevalence of obesity among children. Addressing this issue requires a holistic approach that encompasses dietary modifications, public health initiatives, and clinical vigilance to ensure optimal growth and development for all children.

4 Conclusion

Overall, this study provides insight into the updated prevalence of vitamins A, D, zinc, ferritin, and calcium among Indonesian children under 5 years old who are overweight or obese, demonstrating the existence of a triple burden of malnutrition. In addition, this study suggests that vitamin D deficiency is strongly linked to overweight or obesity. However, the reliance on cross-sectional data in this study served as a limitation, impeding the possibility of making causal inferences. Further studies are necessary to warrant other detrimental factors such as dietary habits, physical activity, socio-economic aspects, and development factors.

References

1. 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, 1–9 (2023). https://doi.org/10.1155/2023/4610038.
2. Arifin AY, Rimbawan R, Riyadi H, Retiaty F, Nurjanah N, Julianti ED, et al. Malnutrition and Calcium Deficiency among Indonesian Under Five-Year-Old Children: Riskesdas 2018 Sample (In Indonesian). *J. Nutr. Food Res.* **47**, 23–32 (2025). https://doi.org/10.36457/pgm.v47i1.781.
3. Castillo-Valenzuela O, Duarte L, Arredondo M, Iñiguez G, Villarroel L, Pérez-Bravo F. Childhood Obesity and Plasma Micronutrient Deficit of Chilean Children between 4 and 14 Years Old. *Nutrients* **15**, 1707 (2023). https://doi.org/10.3390/nu15071707.
4. Luo R, Shi Y, Zhou H, Yue A, Zhang L, Sylvia S, et al. Micronutrient deficiencies and developmental delays among infants: evidence from a cross-sectional survey in rural China. *BMJ Open* **5**, e008400 (2015). https://doi.org/10.1136/bmjopen-2015-008400.
5. Calcaterra V, Verduci E, Milanta C, Agostinelli M, Todisco CF, Bona F, et al. Micronutrient Deficiency in Children and Adolescents with Obesity—A Narrative Review. *Children* **10**, 695 (2023). https://doi.org/10.3390/children10040695.
6. Gu K, Xiang W, Zhang Y, Sun K, Jiang X. The association between serum zinc level and overweight/obesity: a meta-analysis. *Eur. J. Nutr.* **58**, 2971–2982 (2019). https://doi.org/10.1007/s00394-018-1876-x.
7. Tan X, Tan PY, Gong YY, Moore JB. Overnutrition is a risk factor for iron, but not for zinc or vitamin A deficiency in children and young people: a systematic review and meta-analysis. *BMJ Glob. Health* **9**, e015135 (2024). https://doi.org/10.1136/bmjgh-2024-015135.
8. Verma M, Aditi A, Kapoor N, Sharma P, Kakkar M, Kakkar R, et al. Childhood Obesity and Essential Micronutrients: Insights from India's Comprehensive National Nutrition Survey (2016–18). *Diabetes Ther.* **14**, 1267–1283 (2023). https://doi.org/10.1007/s13300-023-01424-2.
9. Ministry of Health of the Republic of Indonesia. *Regulation No. 2 of 2020 on Children Anthropometric Standards* (In Indonesian). (Ministry of Health, Jakarta, 2020).

10. Fiamenghi VI, Mello ED de. Vitamin D deficiency in children and adolescents with obesity: a meta-analysis. *J. Pediatr. (Rio J.)* **97**, 273–279 (2021). https://doi.org/10.1016/j.jped.2020.08.006.
11. Taylor MD, Allada V, Moritz ML, Nowalk AJ, Sindhi R, Aneja RK, et al. Use of C-Reactive Protein and Ferritin Biomarkers in Daily Pediatric Practice. *Pediatr. Rev.* **41**, 172–183 (2020).. https://doi.org/10.1542/pir.2018-0101.
12. Escobedo-Monge MF, Bahillo-Curieses P, Parodi-Román J, Escobedo-Monge MA, Alonso-López P, Marugán-Miguelsanz JM. Calcium, Phosphate, and Vitamin D in Children and Adolescents with Chronic Diseases: A Cross-Sectional Study. *Nutrients* **16**, 1349 (2024). https://doi.org/10.3390/nu16091349.
13. Zou Y, Zhang R, Huang L, Zhao D, Su D, Meng J, et al. Serum levels of vitamin D, retinol, zinc, and CRP in relation to obesity among children and adolescents. *Eur. J. Med. Res.* **27**, 51 (2022). https://doi.org/10.1186/s40001-022-00670-7.
14. Kardaş F, Yücel AD, Kendirci M, Kurtoğlu S, Hatipoğlu N, Akın L, et al. Evaluation of micronutrient levels in children and adolescents with obesity and their correlation with the components of metabolic syndrome. *Turk. J. Pediatr.* **63**, 48–58 (2021). https://doi.org/10.24953/turkjped.2021.01.006.
15. Kulaszyńska M, Kwiatkowski S, Skonieczna-Żydecka K. The Iron Metabolism with a Specific Focus on the Functioning of the Nervous System. *Biomedicines* **12**, 595 (2024). https://doi.org/10.3390/biomedicines12030595.