

A Significant Association Between Nutritional Status and Hypertension Among Adolescents

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ABSTRACT

Hypertension in adolescents is an increasingly significant public health issue. Data from the 2025 Free Health Check-Up (FHC) Program in Magetan Regency reported that 13.4% of senior high school students were pre-hypertensive, 7.0% had Stage 1 hypertension, and 1.6% had Stage 2 hypertension; at SMAN 2 Magetan, the prevalence was even higher at 28.7%, 13.1%, and 2.2%, respectively. Nutritional problems were also prominent, with 29.3% of students undernourished, 8.9% overweight, and 3.5% obese. This study aimed to examine the association between nutritional status and hypertension incidence among Grade X students at SMAN 2 Magetan in 2025. An observational analytic study with a cross-sectional design was conducted. Of 313 Grade X students, 176 were selected through simple random sampling. Nutritional status (BMI, WHO 2007 criteria) was assessed as the independent variable, while hypertension incidence (AAP 2017 criteria) served as the dependent variable. Secondary data from the 2025 FHC Program were analyzed using the Spearman Rank Correlation test ($\alpha = 0.05$). Most students had normal nutritional status (54.55%) and normal blood pressure (43.75%). The Spearman test showed $r = 0.158$ and $p = 0.037$ ($p < 0.05$), indicating a statistically significant but very weak positive correlation between nutritional status and hypertension incidence. As a cross-sectional study relying on single-point blood pressure measurement, causal interpretation and identification of white-coat effects were limited. In conclusion, nutritional status is significantly associated with hypertension incidence among adolescents, although the correlation is very weak. These findings highlight the need for strengthened school-based health promotion to prevent early-onset hypertension and its long-term consequences.

Keywords: nutritional status; hypertension; adolescents

INTRODUCTION

Hypertension, a persistent elevation in blood pressure, is widely referred to as a “silent killer” because it produces minimal or nonspecific symptoms while substantially increasing the risk of stroke, coronary heart disease, heart failure, and other cardiovascular complications [1]. Although historically categorized as a condition of adulthood, hypertension is now increasingly detected in adolescents, reflecting a shift in global epidemiological patterns. Nutritional status, age, and sex have been consistently identified as key determinants that accelerate the early onset of elevated blood pressure in young populations [2]. Because adolescence represents a critical developmental window in which lifelong behavioral and physiological patterns are established, the rising prevalence of hypertension in this age group signals a broader transition toward non-communicable diseases (NCDs) beginning earlier in life [3].

Globally, NCDs account for approximately 41 million deaths each year, representing 74% of all deaths worldwide, with cardiovascular diseases remaining the leading contributor [4]. In Indonesia, the 2023 Indonesian Health Survey (SKI) reported a measured hypertension prevalence of 10.7% among individuals aged 18–24 years and 17.4% among those aged 25–34 years, indicating that elevated blood pressure is already common in early adulthood [5]. East Java Province ranks fourth nationally for hypertension prevalence (34.3%), with more than 8.6 million documented cases in 2023, underscoring the urgency of early detection and prevention strategies [6].

To strengthen upstream prevention, the Indonesian Ministry of Health designated the Free Health Check-Up (FHC) Program as a national priority in 2025. The program targeted more than 53 million students across 282,000 educational institutions and included assessments of nutritional status, blood pressure, physical fitness, dental–visual–hearing health, mental health, and immunization history. In Magetan Regency, FHC 2025 data showed that 15.6% of senior high school students were overweight and 4.5% obese, while 13.4% were pre-hypertensive, 7.0% had Stage 1 hypertension, and 1.6% had Stage 2 hypertension. At SMAN 2 Magetan, located within the working area of Puskesmas Candirejo, both nutritional and blood pressure problems were even more pronounced. Of 313 Grade X students examined, 29.3% were undernourished, 8.9% overweight, and 3.5% obese, while 28.7% were pre-hypertensive and 15.3% met hypertension criteria.

Elevated BMI is a well-established predictor of hypertension through multiple physiological mechanisms, including sympathetic nervous system overactivity, renin–angiotensin–aldosterone system (RAAS) activation, insulin resistance, endothelial dysfunction, and low-grade chronic inflammation [7–10]. These pathways collectively contribute to increased vascular resistance and impaired blood pressure regulation. Despite the availability of standardized, population-level FHC data, no study has specifically examined the relationship between nutritional status and hypertension among Grade X students at SMAN 2 Magetan. Utilizing this comprehensive school-based dataset offers an efficient, representative, and cost-effective alternative to primary data collection and can inform targeted preventive interventions at both school and district levels. Therefore, this study aims to analyze the association between nutritional status and hypertension incidence among Grade X students at SMAN 2 Magetan in 2025.

METHODS

This study employed an observational analytic design with a cross-sectional approach. The research was conducted at SMAN 2 Magetan, in the working area of Puskesmas Candirejo, Magetan Regency, East Java, Indonesia. Data collection was based on secondary data from the 2025 FHC Program, with data analysis conducted between January and May 2026.

The study population comprised all 313 Grade X students at SMAN 2 Magetan registered in the 2025 FHC database. Sample size was calculated using the Slovin formula with a 95% confidence level and 5% margin of error, yielding $n = 176$ students. Simple random sampling was applied via Microsoft Excel randomization. Inclusion criteria were: Grade X students with complete CKG data entries (weight, height, BMI, and blood pressure), age < 17 years, and active enrollment status. Students with incomplete anthropometric or blood pressure data were excluded. The independent variable was nutritional status, operationalized as BMI (kg/m^2) calculated from CKG measurement data, classified by WHO 2007 standards: underweight ($< 18.5 \text{ kg}/\text{m}^2$), normal ($18.5\text{--}22.9 \text{ kg}/\text{m}^2$), overweight ($23.0\text{--}24.9 \text{ kg}/\text{m}^2$), and obese ($25\text{--}29.9 \text{ kg}/\text{m}^2$). The dependent variable was hypertension incidence, classified using AAP 2017 absolute cut-off criteria: normal ($< 120/80 \text{ mmHg}$), elevated blood pressure/pre-

hypertension (120–129/<80 mmHg), Stage 1 hypertension (130–139/80–89 mmHg), and Stage 2 hypertension ($\geq 140/90$ mmHg). Both variables are ordinal-scaled.

Data were processed through editing, cleaning, coding, data entry, and tabulating. Descriptive analysis presented frequency distributions by nutritional status and blood pressure category. Analytical testing employed the Spearman Rank Correlation test, appropriate for two ordinal variables without assuming normal distribution (significance level $\alpha = 0.05$). Cross-tabulation was performed to examine the pattern of hypertension distribution across nutritional status categories. Statistical analysis was performed using SPSS. As blood pressure was measured at a single time point rather than through repeated ambulatory monitoring, this limitation is considered when interpreting the results. Data were processed through editing, cleaning, coding, data entry, and tabulating. Descriptive analysis presented frequency distributions by nutritional status and blood pressure category. Analytical testing employed the Spearman Rank Correlation test, appropriate for two ordinal variables without assuming normal distribution (significance level $\alpha = 0.05$). Cross-tabulation was performed to examine the pattern of hypertension distribution across nutritional status categories. Statistical analysis was performed using SPSS. As blood pressure was measured at a single time point rather than through repeated ambulatory monitoring, this limitation is considered when interpreting the results.

The study adhered to the principles of research ethics. Ethical clearance with Exempted status was obtained from the Research Ethics Committee of Poltekkes Kemenkes Surabaya. Research permission was secured from the Magetan Regency Health Office and Puskesmas Candirejo. Data confidentiality was maintained through full anonymization of all student records, with data used solely for research purposes.

RESULTS

A total of 176 Grade X students from SMAN 2 Magetan met the inclusion criteria. Of these, 119 (67.61%) were female and 57 (32.39%) were male. Distribution of nutritional status categories is presented in Table 1, blood pressure categories in Table 2, and the cross-tabulation of hypertension by nutritional status in Table 3.

The majority of students (54.55%) had normal nutritional status. Undernutrition was observed in 25.57% of students, while 19.32% were overweight and 0.57% ($n = 1$) were obese (Table 1). Normal blood pressure was found in 43.75% of students. Pre-hypertension was present in 13.07%, Stage 1 hypertension in 31.25%, and Stage 2 hypertension in 11.93% of students (Table 2). Combined, 56.25% of students had blood pressure above normal levels.

Cross-tabulation (Table 3) showed that normal blood pressure was most prevalent among students with undernutrition (53.3%) and normal nutritional status (43.8%). Stage 1 hypertension was most prevalent among overweight students (41.2%), and combined Stage 1 and Stage 2 hypertension was highest in the overweight group (61.8%). The Spearman Rank Correlation test yielded $r = 0.158$ and $p = 0.037$ ($p < 0.05$), indicating a statistically significant positive correlation with very weak strength between nutritional status and hypertension incidence.

Table 1. Distribution of nutritional status among grade X students at SMAN 2 Magetan

Nutritional status	Frequency	Percentage
Underweight	45	25.57
Normal	96	54.55
Overweight	34	19.32
Obese	1	0.57

Table 2. Distribution of blood pressure categories among grade X students at SMAN 2 Magetan

Blood pressure	Frequency	Percentage
Normal	77	43.75
Pre-hypertension	23	13.07
Stage 1 hypertension	55	31.25
Stage 2 hypertension	21	11.93

Table 3. Cross-tabulation of hypertension incidence by nutritional status among grade X students at SMAN 2 Magetan in 2025

Nutritional status	Normal: f (%)	Pre-HT: f (%)	HT Stage 1: f (%)	HT Stage 2: f (%)
Underweight	24 (53.3)	5 (11.1)	11 (24.4)	5 (11.1)
Normal	42 (43.8)	15 (15.6)	30 (31.3)	9 (9.4)
Overweight	10 (29.4)	3 (8.8)	14 (41.2)	7 (20.6)
Obese	1 (100)	0 (0)	0 (0)	0 (0)

DISCUSSION

This study identified a statistically significant positive association between nutritional status and hypertension incidence among Grade X students at SMAN 2 Magetan ($r = 0.158$; $p = 0.037$). Although the correlation coefficient was small, its statistical significance indicates that nutritional status plays a measurable role in shaping blood pressure profiles among adolescents. The modest strength of the correlation reflects the complex, multifactorial nature of hypertension, particularly in younger populations where biological, behavioral, and environmental determinants interact dynamically. Nevertheless, the positive direction of the association suggests that as nutritional status shifts toward overweight and obesity, the likelihood of elevated blood pressure increases, reinforcing the established understanding that excess adiposity contributes to cardiovascular strain.

The physiological mechanisms underlying this relationship are well documented. Increased adiposity activates the sympathetic nervous system, stimulates the renin–angiotensin–aldosterone system (RAAS), promotes insulin resistance, impairs endothelial function, and triggers chronic low-grade inflammation mediated by adipokines such as TNF- α and IL-6 [11,12]. Visceral fat, in particular, is metabolically active and capable of producing angiotensinogen and renin, thereby contributing directly to vasoconstriction, sodium retention, and increased vascular resistance [10]. These mechanisms can occur even before adolescents reach full obesity, meaning that overweight status alone may be sufficient to elevate blood pressure. This physiological pattern is reflected in the study's cross-tabulation results, where Stage 1 hypertension was most prevalent among overweight students (41.2%), and 61.8% of overweight students exhibited either Stage 1 or Stage 2 hypertension.

The findings of this study align with global and national evidence. A meta-analysis involving 98,756 adolescents demonstrated that obese adolescents had nearly four times the risk of hypertension compared with normal-weight peers (OR = 3.96; 95% CI: 3.20–4.90) [13]. A systematic review of 37 journals similarly confirmed significant BMI–hypertension associations across 22 studies [14]. Local studies in Indonesia, including school-based research in Semarang [15] and a Spearman correlation analysis among 125 high school students [16], reported comparable findings, reinforcing the consistency of the BMI–hypertension relationship across diverse adolescent populations.

Beyond overweight and obesity, this study also revealed a dual burden of malnutrition, with 25.57% of students undernourished and 19.89% overweight or obese. This pattern reflects the nutritional transition occurring in semi-rural regions such as Magetan Regency, where traditional dietary patterns coexist with increasing access to energy-dense foods. The thrifty phenotype hypothesis provides a compelling explanation: early-

life undernutrition may induce epigenetic modifications that enhance metabolic efficiency and RAAS sensitivity, predisposing individuals to hypertension when later exposed to caloric abundance [17]. This hypothesis may explain why hypertension was also observed among undernourished students, suggesting that both ends of the nutritional spectrum contribute to cardiovascular risk.

The weak correlation coefficient observed in this study is consistent with the multifactorial nature of adolescent hypertension. Numerous determinants not examined here likely contribute substantially to blood pressure variation. These include physical activity levels, dietary sodium intake, consumption of ultra-processed foods, sleep duration and quality, family history of hypertension, psychological stress, hormonal fluctuations associated with puberty, and environmental factors such as school workload and peer dynamics [18]. Prior Indonesian studies have identified physical inactivity and limited hypertension awareness as major risk factors among adolescents [19]. The high proportion of students (56.25%) with above-normal blood pressure is clinically significant, particularly because adolescent hypertension is often asymptomatic and may remain undetected without systematic school-based screening programs such as the CKG Sekolah initiative.

From a midwifery and reproductive health perspective, the implications of adolescent hypertension extend beyond adolescence. Female adolescents with pre-existing hypertension face increased risks of gestational hypertension, preeclampsia, intrauterine growth restriction, low birth weight, and preterm delivery in future pregnancies [20]. Early identification and management of hypertension in adolescents therefore have long-term benefits for maternal and neonatal health outcomes [21].

The use of standardized FHC secondary data is a methodological strength that enhances representativeness, reduces measurement bias, and allows efficient analysis of large student populations. However, several limitations must be acknowledged to contextualize the findings. Despite the strengths of using standardized, population-level FHC secondary data, this study has several limitations. The cross-sectional design restricts causal inference [22], preventing determination of whether nutritional status directly influences blood pressure or whether both are shaped by shared underlying factors. Blood pressure was measured at a single time point without ambulatory or repeated measurements, increasing the possibility of white-coat effects and reducing diagnostic precision. Important confounding variables, such as dietary sodium intake, physical activity, sleep patterns, stress levels, and family history were not included, limiting the ability to fully explain blood pressure variability. Future research employing longitudinal designs, repeated blood pressure measurements, and more comprehensive behavioral and biological variables is recommended to better elucidate the dynamics of adolescent hypertension.

Future research should adopt longitudinal designs, incorporate repeated blood pressure measurements, include comprehensive behavioral and biological variables, and utilize more sensitive indicators of adiposity. Such approaches would provide deeper insights into the dynamics of adolescent hypertension and strengthen evidence for targeted interventions.

CONCLUSION

This study found a significant positive association between nutritional status and hypertension among Grade X students at SMAN 2 Magetan. Adolescents with higher nutritional status categories tended to show higher blood pressure classifications, while the coexistence of undernutrition, overweight, and obesity indicated a dual burden of malnutrition. These patterns highlight that both ends of the nutritional spectrum contribute to cardiovascular risk in this population.

The findings underscore the need for routine school-based health screening and integrated education on balanced nutrition and cardiovascular health. Collaborative programs between schools and primary healthcare facilities should address undernutrition and overweight simultaneously to prevent early-onset hypertension. Future research should use longitudinal designs and include additional determinants; such as physical activity, sodium intake, sleep quality, and family history to better capture the multifactorial nature of adolescent hypertension.

Ethical consideration, competing interest and source of funding

- This study adhered to ethical principles for research involving human participants. Ethical clearance with Exemption status was obtained from the Research Ethics Committee of Poltekkes Kemenkes Surabaya (No. EA/4462/KEPK-Poltekkes_Sby/V/2026). Secondary data were used with full official permission from Magetan Regency Health Office and Puskesmas Candirejo. Confidentiality was maintained through anonymization of all participant data.
- There is no conflict of interest related to this publication.
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