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Factors Contributing to the Blood Pressure of High School Students in Depok, West Java

Faktor yang Mempengaruhi Tekanan Darah pada Remaja SMA di Depok, Jawa Barat

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ABSTRACT

Background: Hypertension is a major global health concern, contributing to high mortality rates among adults and the elderly. Recent trends show a substantial upsurge in hypertension prevalence among adolescents. According to the Health Office of Depok City, 78.10% of adolescents aged ≥15 years are reported to have hypertension. Hypertension during adolescence often persists into adulthood, increasing the risk of long-term morbidity and mortality. The primary contributors include unhealthy lifestyle practices and poor dietary habits.
Objectives: To investigate factors associated with elevated blood pressure among adolescents in Depok City, West Java, Indonesia.
Methods: A cross-sectional study was conducted with 158 adolescents selected through stratified random sampling. Data collection took place between February to April 2024. Variables assessed included family history of hypertension, nutritional status (based on Body Mass Index categories as per the 2020 Ministry of Health regulation), and stress levels (measured using the Perceived Stress Scale). Statistical analysis employed chi-square tests and multiple logistic regression.
Results: Significant associations were found between hypertension and family history (p-value = 0.034), nutritional status (p-value = 0.014), and stress levels (p-value < 0.001). Multivariate analysis indicated that stress levels were the strongest determinant of hypertension (OR = 6.09).
Conclusions: Stress levels significantly influence blood pressure in adolescents. Schools should prioritize regular programs addressing stress management, emotional well-being, and balanced nutrition education to reduce the risk of adolescent hypertension.

INTRODUCTION

Hypertension, nowadays, remains a significant contributor to global mortality rates. While it is predominantly associated with adults and the elderly, increasing prevalence among adolescents has been documented[1]. For example, a study in China reported that 18.6% of 7,786 adolescents across six provinces experienced hypertension[2]. Similarly, research conducted in Tunisia found hypertension in 15.4% of 1,385 student participants[3]. In Indonesia, the prevalence of hypertension in adolescents has also been increasing, particularly in the 15–18-year age group. According to the 2013 Basic Health Research Survey (Riskesdas), 6.9% of adolescents in Indonesia have hypertension[4]. More recent data from the Depok City Health Office in 2022 indicated that 78.1% (379,903 of 486,415) of hypertensive cases occurred in individuals aged ≥15 years. Additionally, other studies in Depok revealed that 42.45% of high school students and 57.1% of adolescents aged 12–25 years were hypertensive, highlighting an alarming trend among the younger population[5,6].

Adolescence represents a transitional phase characterized by significant physical, cognitive, and psychosocial development. These rapid changes can influence decision-making, emotional regulation, and lifestyle choices[7]. During this period, adolescents are particularly susceptible to environmental influences, including family, school, peers, and social media, which may encourage unhealthy behaviors. These behaviors, in turn, elevate the risk of health issues such as hypertension.

The aetiology of hypertension in adolescents involves both internal and external factors. Key contributors include family history, nutritional status, and stress levels[8–10]. The family history of hypertension contributes significantly to the incidence of hypertension in adolescents. Those with a family history of hypertension are 3.9 times more likely to develop hypertension than those without[5]. Research from the

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Baunase Health Center in Kupang City further supports this, demonstrating a strong association between genetic predisposition and elevated blood pressure in adulthood (p-value < 0.001)[11]. The determinants of hypertension are categorized into modifiable and non-modifiable factors. Modifiable factors include lifestyle behaviors such as diet, physical activity, and stress management. Non-modifiable factors include genetic predisposition and inherent biological characteristics. For instance, adolescents with a history of overeating are 65–75% more likely to develop hypertension[12].

The 2018 Riskesdas reported a 4.4% increase in the prevalence of obesity in adolescents compared to 2013, further linking nutritional status to hypertension risk. Adolescents with overweight and obesity were 3.51 times more likely to develop hypertension compared to those with normal nutritional status[13]. The ineffective management of stress is also a significant factor that can contribute to the onset of hypertension in adolescents. Those who experience stress have a 23.95% risk of developing high blood pressure compared to those who do not experience stress. Additionally, females are observed to have a 95% higher risk of hypertension than males. Poor stress management triggers the release of hormones such as adrenaline, thyroxine, and cortisol, leading to increased heart rate and vascular resistance[10].

Despite the existing evidence linking family history, nutritional status, and stress to adolescent hypertension, research in Depok City remains limited. This study aims to identify and analyze factors associated with elevated blood pressure among adolescents in Depok City, West Java.

METHODS

Design, Time, and Place

This cross-sectional study investigated the association between variables at a single point in time. The study focused on students in grades X and XI (ages 15–18 years) at Raflesia Integrated Islamic High School, conducted from February to April 2024. Ethical approval was obtained from the Health Research Ethics Commission of UPN "Veteran" Jakarta on March 20, 2024 (Approval Number: 89/III/2024/KEP).

Sampling Size and Technique

The sample size in this study is determined using the Slovin formula, a common method to calculate the number of samples if the population is known. The study population comprised 261 students in grades X and XI of Raflesia Integrated Islamic High School. Based on the calculation, the required sample size was 158 respondents, ensuring a representative sample with a specified margin of error.

A stratified random sampling method was employed to achieve proportional representation and enhance the validity of the results. This technique divided the population into strata based on specific criteria, with random samples selected from each stratum using a randomization tool. Stratified random sampling ensures that each subgroup within the population is adequately represented, allowing for a more accurate reflection of the population as a whole.

Sampling was conducted with careful consideration of the predetermined inclusion and exclusion criteria. Inclusion criteria specified that participants must be students aged 15–18 years, officially registered as active students at Raflesia Integrated Islamic High School, and willing to participate by providing signed informed consent. Additionally, participants were required to be physically and mentally healthy, without any intellectual, emotional, or social limitations that could interfere with the data collection process or compromise the study results. Exclusion criteria eliminated individuals who were unable to attend the data collection sessions due to illness or other reasons, as well as those who refused to sign the informed consent or declined participation in the study. By rigorously applying these inclusion and exclusion criteria, the researchers ensured that the selected sample was representative of the target population and relevant to the study objectives while minimizing potential bias resulting from inappropriate respondent selection.

Data Collection Procedure

This study collected both primary and secondary data. The primary data included demographic characteristics such as respondents' names, ages, and genders, alongside the measurements of blood pressure as dependent variables and independent variables including family history of hypertension, nutritional status, and stress levels. Data collection was performed systematically through the distribution of questionnaires to students. Enumerators supervised the completion of these questionnaires to ensure data accuracy and consistency. Blood pressure, a key dependent variable in this study, was measured by trained enumerators certified in blood pressure measurement techniques. Measurements were conducted using standardized Omron digital sphygmomanometers. The obtained blood pressure data were classified based on the American Academy of Pediatrics (AAP) 2017 guidelines to ensure the results meet applicable international standards. The blood pressure variable was divided into five categories: normal (<120/<80 mmHg), Pre-hypertension (120/<80 - 129/<80 mmHg), Grade 1 Hypertension (130/80 -139/89 mmHg), and Grade 2 Hypertension (≥140/90 mmHg). For analytical purposes, these categories were then divided into two groups: “Normal Blood Pressure” (<120/<80 mmHg) and “Hypertension” (≥120/≥80 mmHg).

Anthropometric data, including weight and height, were collected by enumerators using digital scales and height-measuring instruments called microtoise. Following data collection, the nutritional status was assessed using the Body Mass Index-for-Age (BMI/U) Z-score, adhering to the anthropometric standards outlined in the Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2020. This regulation defines malnutrition as a Z-score between -2 SD and +1 SD and obesity as a Z-score greater than +2 SD. However, this study utilized only the normal (-2 SD to +1 SD) and overnutrition (>+1 SD) categories.

The questionnaire used to assess the family history of hypertension consisted of a single question directly asking respondents if any family members had been diagnosed with or had a history of hypertension. The response options were dichotomous: "Yes" or "No."

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Furthermore, the level of stress experienced by respondents was measured using the Perceived Stress Scale (PSS), a validated instrument comprising ten questions designed to evaluate physical and mental stress over the past month. Six of the questions were negatively framed to measure the extent of stress and pressure perceived in daily life, while the remaining four were positively framed to assess coping mechanisms and adaptability. Responses for each question were scored on a scale from 0 to 4, reflecting the frequency or intensity of the stress experienced. The total score, obtained by summing all responses, provided a comprehensive measure of stress levels. The stress categories used in this study were: "Not Having Stress" (score 0-26) and "Having Stress" (score 27-40).

Data Analysis

Data analysis for this study was conducted using Microsoft Excel 2013 and the Statistical Package for Social Sciences (SPSS) for Windows, with the degree of significance determined at 5% (p-value = 0.05). A comprehensive analytical approach was adopted, encompassing univariate, bivariate, and multivariate analyses to ensure a thorough understanding of the data. Univariate analysis was performed as an initial step to describe the distribution and characteristics of the respondents. This analysis provided an overview of essential variables such as age, gender, and other demographic or study-specific factors, offering researchers foundational insights into the dataset. Once this preliminary understanding was established, bivariate analysis was conducted to explore associations between independent and dependent variables. This stage aimed to identify significant associations or associations, helping to discern patterns or trends within the data. The final stage of the analysis involved multivariate analysis using the multiple logistic regression method. This method was selected to identify the key factors among the various independent variables affecting the dependent variable. By adjusting for potential confounding variables, multiple logistic regression allowed the identification of the strongest predictors or determinants related to hypertension.

RESULTS AND DISCUSSIONS

Table 1 presents the age distribution of adolescents enrolled at Raflesia Integrated Islamic High School, demonstrating that out of the 158 respondents, the most significant proportion, consisting of 73 individuals (46.2%), was 16 years old. This age group falls within the middle adolescence stage, a developmental phase often characterized by heightened sensitivity to external influences and a strong inclination to explore new experiences. Adolescents in this age range are particularly vulnerable to adopting unhealthy lifestyle behaviors, including unbalanced dietary patterns characterized by excessive intake of fat and sodium, insufficient physical activity, poor sleep hygiene, and inadequate stress management practices. These factors underscore the critical importance of monitoring lifestyle and dietary habits during this formative period, as these behaviors can exert long-term effects on health outcomes extending into adulthood.

The frequency distribution of sex characteristics indicates that the majority of respondents were female, accounting for 102 individuals (64.6%). This predominance of female respondents reflects the gender distribution at the school, where the number of female students exceeds that of males. This finding aligns with previous studies conducted among adolescents aged 15–19 years. For instance, research involving vocational school students in Bantul District reported that the female adolescent population (n=173) significantly outnumbered their male counterparts (n=27)[14]. Similarly, another study documented a higher prevalence of female adolescents (n=67) compared to males (n=16)[16]. These consistent observations suggest that gender disparities in adolescent populations are a recurring phenomenon in educational settings.

Table 1. Frequency Distribution Characteristics of High School Students in Depok, West Java.

Characteristic	n	%
Age		
15 Years	10	6.3
16 Years	73	46.2
17 Years	66	41.8
18 Years	9	5.7
Sex		
Male	56	35.4
Female	102	64.6

Table 2. Analysis of the association between family history of hypertension, nutritional status, and stress levels of high school adolescents in Depok, West Java

Variable	Categories Blood Pressure				Total		*p-value*	*PR (95% CI)*
	Normal Blood Pressure		Hypertension					
	n	%	n	%	n	%		
Family History of Hypertension								
No	91	57.6	11	6.9	102	64.5		
Yes	42	26.6	14	8.9	56	35.5	**0.034***	**1.189**
Total	**133**	**84.2**	**25**	**15.8**	**158**	**100.0**		(0.28-0.43)

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Nutritional Status (BMI-for-age Z-score)								
Normal	95	60.1	11	6.9	106	67.0		
Overnutrition	38	24.1	14	8.9	52	33.0	**0.014***	**1.227** (0.68–0.88)
Total	**133**	**84.2**	**25**	**15.8**	**158**	**100.0**		
Stress Levels								
Not Having Stress	120	75.9	14	8.9	138	84.8		
Having Stress	13	8.2	11	7.0	24	15.2	**<0.001***	**1.606** (0.10-0.21)
Total	**130**	**84.1**	**25**	**15.9**	**158**	**100.0**		

*PR (*Prevalence Ratio*); CI (*Confidence Interval*)

The Association between Family History of Hypertension and Blood Pressure in Adolescents

The analysis of the association between family history of hypertension and blood pressure among adolescents revealed distinct trends. Among respondents without a family history of hypertension, 91 individuals (57.6%) exhibited normal blood pressure, while 11 individuals (6.9%) were classified in the hypertension category. Conversely, among those with a family history of hypertension, 42 respondents (26.6%) exhibited normal blood pressure, while 14 respondents (8.9%) were classified in the hypertension category. A chi-square statistical test yielded a p-value of 0.034, indicating a statistically significant association between familial hypertension and adolescent blood pressure levels. The calculated PR of 1.189 further suggests that adolescents with a family history of hypertension are 1.189 times more likely to develop hypertension than those without the disease in their family history.

These findings align with the research of Lawalata *et al* (2023), who reported a strong association between genetic predisposition and hypertension in adolescents, with a p-value of 0.000 and an OR of 5.056. This study underscored that adolescents with a family history of hypertension are five times more likely to develop the condition compared to their counterparts without a family history of hypertension[17]. Similarly, Mulyasari *et al* (2023) study also found a significant association between a family history of hypertension and adolescent hypertension, with a reported p-value of 0.017 and an OR of 2.600[18]. Collectively, these studies emphasize the critical role of family history of hypertension factors in increasing the risk of this disease in adolescents, highlighting the substantial contribution of genetic predisposition to the development of this condition.

The occurrence of hypertension in adolescents is profoundly influenced by hereditary factors, as parental hypertension is a significant determinant of genetic predisposition and familial patterns of parenting[17]. Genetic factors contributing to hypertension risk encompass monogenic forms caused by mutations in specific genes and polygenic hypertension, involving the interaction of multiple genes. However, the impact of a family history of hypertension on adolescents varies across different socioeconomic, environmental, and ethnic contexts. Polygenic hypertension, driven by numerous genetic loci, is believed to have a predominant role in the disease's development[5,18]. Polygenic hypertension results from the interplay of various genetic systems within the body, including the renin-angiotensin-aldosterone (RAA) system, the G protein signal transduction pathways, noradrenergic structures, ion channels, α-adrenergic receptors, as well as the immune and inflammatory systems, among other genetic factors[13]. This intricate combination of genetic influences significantly increases the predisposition to hypertension, particularly when compounded by environmental and lifestyle factors. These interactions highlight the multifactorial nature of hypertension, emphasizing the importance of considering genetic and non-genetic contributors in understanding its development, especially among the younger population.

Associations between Nutritional Status and Adolescent Blood Pressure

The analysis of the association between nutritional status, which is categorized based on Body Mass Index-for-Age Z-score, and adolescent blood pressure revealed significant findings. Among respondents with normal nutritional status, 95 adolescents (60.1%) had blood pressure in the non-hypertensive category, while 11 adolescents (6.9%) were classified as hypertensive. Conversely, of the respondents with overnutrition, 38 (24.1%) exhibited blood pressure in the non-hypertensive category, and 14 (8.9%) were classified as hypertensive. The chi-square test yielded a statistically significant association (p-value=0.014), indicating a significant association between nutritional status (according to BMI-for-Age Z-score) and blood pressure in adolescents. Additionally, PR of 1.227 suggests that adolescents with overnutrition were 1.227 times more likely to develop hypertension compared to their peers with normal nutritional status.

These results align with the findings of a study conducted by Nuradina *et al* (2023), who demonstrated a significant association between nutritional status and hypertension in adolescents, with a highly significant p-value of 0.001 and an OR of 6.13. Their study indicated that adolescents with overnutrition have a sixfold higher risk of experiencing increased blood pressure than those with normal nutritional status[19]. Similarly, research conducted by Nurkhofifah & Putriningtyas (2023) supported these conclusions, reporting a significant association between nutritional status and adolescent hypertension, with a p-value of 0.047[20]. Further corroboration comes from Taghizadeh *et al* (2021), whose findings also demonstrated a significant association between nutritional status and hypertension risk in adolescents (p-value=0.007). These studies collectively emphasize the critical need to monitor and manage nutritional status as a preventive measure against hypertension in the adolescent population[21].

Excessive weight gain, particularly with increased visceral fat, is a prominent factor contributing to hypertension in adolescents. This condition is heavily influenced by lifestyle factors such as dietary habits and

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physical activity levels. Hypertension in overweight individuals arises from several complex mechanisms rather than a single causative pathway. Insulin resistance is a key factor wherein the body's inability to effectively use insulin leads to elevated blood glucose levels. Sodium retention further exacerbates the condition by increasing blood volume and blood pressure. Elevated sympathetic nervous system activity, a stress response, also increases blood pressure. Additionally, activation of the RAA system, which regulates blood pressure and fluid balance, induces vasoconstriction, further elevating blood pressure. Reduced vascular elasticity and endothelial dysfunction in individuals with overnutrition further aggravate the risk of hypertension[20].

In adolescents with overnutrition, resting cardiac output increases as the heart works harder to meet the body's demands. Thickening of the carotid artery walls, common in overnourished individuals, further contributes to elevated blood pressure. The visceral fat accumulation exacerbates insulin resistance and impairs endothelial function, leading to narrowed blood vessels and increased blood pressure. Furthermore, excess sodium absorption in these individuals adds to the hypertensive risk[23].

As highlighted by Tika, Maelani and & Cahyati (2019), obesity is strongly linked to hypertension, as the increased body mass necessitates a higher blood volume to supply nutrients to body tissues. This larger blood volume increases pressure on arterial walls, significantly raising blood pressure and heightening the risk of hypertension. Thus, maintaining a healthy weight is imperative to prevent hypertension, particularly during adolescence—a critical developmental period where lifestyle habits can have long-term health implications[24].

The Association between Stress Levels and Adolescent Blood Pressure

This study investigated the association between stress levels and blood pressure in adolescents. Among respondents who did not experience stress, 120 (75.9%) had normal blood pressure (non-hypertension), while 14 (8.9%) were classified as hypertensive. In contrast, among those experiencing stress, only 13 (8.2%) had normal blood pressure, whereas 11 (7.0%) were hypertensive. Chi-square analysis revealed a statistically significant association between stress levels and blood pressure (p-value < 0.001). These findings suggest that stress contributes to increased blood pressure in adolescents. Furthermore, the prevalence ratio (PR) of 1.606 indicates that adolescents experiencing stress are 1.606 times more likely to develop hypertension compared to those without stress.

The results of this study are in line with the findings reported by Lawalata (2023), which reported a strong association between stress levels and hypertension among adolescents, with a highly significant p-value (< 0.001) and a high odds ratio (OR) of 10.815. This indicates that adolescents experiencing stress are ten times more likely to develop hypertension[17]. Similarly, Delavera's (2021) study also found a statistically significant association between stress levels and blood pressure in adolescents (p-value = 0.024), with an OR of 1.12, suggesting that increased stress is associated with increased blood pressure. These studies consistently demonstrate that stress is a significant risk factor for hypertension development in adolescents, highlighting the importance of stress management in hypertension prevention[10].

Stress is a physiological response to emotional discomfort, characterized by the release of stress hormones as a protective mechanism[10]. When stressed, the kidneys are stimulated to produce adrenal hormones, which increase heart rate and contractility, ultimately elevating blood pressure. Chronic stress can lead to sustained hypertension. Furthermore, chronic stress can disrupt the adrenal glands and thyroid function, affecting the production of hormones such as adrenaline, cortisol, and thyroxine. Increased adrenaline production disrupts homeostasis, as adrenaline, working through the sympathetic nervous system, significantly increases heart rate and contributes to elevated arterial pressure[22]. This finding suggests that not only is stress itself detrimental, but its long-term impact on hormonal function and the nervous system can exacerbate high blood pressure conditions.

The sympathetic nervous system plays a crucial role in responding to hypothalamic stimuli by activating various organs and smooth muscles. It also signals the adrenal medulla to release epinephrine and norepinephrine into the bloodstream. These hormones, along with adrenaline, thyroxine, and cortisol (stress hormones), increase when the body is under pressure. The synergistic action of adrenaline and the sympathetic nervous system leads to vasoconstriction, narrowing blood vessels, which increases blood volume and consequently, blood pressure[25]. This combined effect of increased stress hormones and sympathetic nervous system activation significantly contributes to elevated blood pressure.

Predominant Factors Associated with Hypertension Prevalence in Adolescents

Table 3. The multiple logistic regression analysis test results

Variable	p-value	OR	95% CI	
			Lower	Upper
Family History of Hypertension	0.192	1.899	0.724	4.980
Nutritional Status (BMI-for-Age)	0.024	2.979	1.155	7.680
Stress Levels	0.001	6.095	2.132	17.423

*OR (*Odds Ratio*); CI (*Confidence Interval)*

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Multivariate analysis, as shown in Table 3, indicates that while family history of hypertension did not directly correlate with hypertension in adolescents. However, the test results produce an OR, which indicates that adolescents with a family history of hypertension are 1.8999 times more likely to experience hypertension than those without a family history of having the disease. This finding suggests that although family history is not the primary cause, adolescents with a family history of hypertension have a potential risk of developing the disease.

Nutritional status, assessed using Body Mass Index for Age (BMI-for-age), was significantly associated with hypertension. Adolescents with overnutrition status (including respondents with overweight or obesity) were 2.979 times more likely to develop hypertension compared to those with normal nutritional status. This highlights the crucial role of nutritional status in increasing hypertension risk among adolescents.

Table 3 identified stress as a significant predictor of hypertension in adolescents at Raflesia Integrated Islamic High School (p-value < 0.001, OR: 6.095, 95% CI: 2.132 – 17.423). Adolescents experiencing stress were six times more likely to develop hypertension compared to those without stress. These findings align with Kurnianto *et al* (2020) cross-sectional study, which, identified stress as the primary cause of hypertension among adolescents (OR: 5.83, 95% CI: 2.91 – 11.6). Another study demonstrated that adolescents with high-stress levels had a 3.52 times higher risk of hypertension compared to those with low stress levels (OR: 3.52, 95% CI: 1.64 – 5.39, p-value < 0.001)[15]. These findings emphasize the critical role of stress management in hypertension prevention among adolescents.

Stress is a physiological response to emotional discomfort, characterized by the release of stress hormones[10]. When stressed, the kidneys release adrenal hormones, which increase heart rate and contractility, leading to elevated blood pressure. Chronic stress can lead to sustained hypertension. Prolonged stress can also disrupt the function of the adrenal glands and thyroid, affecting the production of hormones such as thyroxine, adrenaline, and cortisol. This hormonal imbalance disrupts homeostasis, contributing to increased heart rate and arterial pressure[22].

Adolescents experiencing severe stress are more susceptible to hypertension. Excessive stress can negatively impact the physical and psychological development of adolescents, increasing their vulnerability to environmental influences[27]. Moreover, stress often triggers unhealthy behaviors in adolescents, such as inadequate sleep, consumption of high-sodium, high-sugar, and high-saturated-fat foods, and smoking. These behaviors significantly increase the risk of hypertension among the 28 adolescents. Understanding the impact of stress on adolescent physical and mental health is crucial for effective hypertension prevention strategies.

The strength of this study includes the utilization of the latest cut-off points for childhood hypertension as defined by the American Academy of Pediatrics in 2017. However, limitations include limited interview time with each adolescent, which may have impacted data collection. Additionally, potential inaccuracies may have arisen from recall bias in the application of SQ-FFQ due to its reliance on dietary intake information from the past month, which involves long-term memories of the respondents. Repeated probing and questioning were employed to mitigate this limitation.

CONCLUSIONS

This study found a significant association between family history of hypertension and nutritional status (as measured by Body Mass Index for Age, or BMI-for-age) and blood pressure in adolescents. These findings suggest that both a family history of hypertension and an adolescent's nutritional status may contribute to their blood pressure levels. However, further analysis revealed that stress was the most significant factor influencing elevated blood pressure in this adolescent population. High-stress levels can exert considerable strain on the cardiovascular system, contributing more significantly to blood pressure elevation than other factors examined. These findings underscore the crucial importance of incorporating stress management strategies into efforts to prevent and manage hypertension in adolescents, who may be particularly vulnerable to the detrimental effects of stress on their heart health.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflicts of interest. This research was conducted independently and without external funding.

AUTHOR CONTRIBUTIONS

NT: conceptualization, investigation, methodology, analysis, original drafting, and editing; NIS: reviewing the article, conducting supervision, and editing; AF: reviewing the article, conducting supervision, and editing.

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