Journal Interdisciplinary Health

Volume 1 Issue 3, November 2025, p. 81-90
DOI: https://doi.org/10.61099/jih.v1i3.138

Original Article *Open Access*

Association of family history and physical activity with hypertension in pre-elderly adults

Suprapto [a]*, Nurafriani[b], Sitti Nurbaya[b]

[a] Departement of Nursing, Politeknik Sandi Karsa, South Sulawesi, Indonesia
[b] Departement of Nursing, STIKES Nani Hasanuddin Makassar, South Sulawesi, Indonesia

*Correspondence: Suprapto, Departement of Nursing, Politeknik Sandi KArsa, South Sulawesi, Indonesia.
Email: atoenurse@gmail.com

Received: September 10, 2025 ○ Revised: Oktober10, 2025 ○ Received: Oktober 30, 2025 ○ Published: November 10, 2025

ABSTRACT

Introduction: Hypertension remains a significant public health problem globally, particularly among pre-elderly adults (aged 45–59 years), who are at increased risk of developing cardiovascular disease. Both genetic predisposition and lifestyle factors, such as physical activity, play crucial roles in determining hypertension risk. Understanding how family history interacts with physical activity can provide valuable insights for prevention strategies among this population.

Methods: This cross-sectional study aimed to analyze the association between family history of hypertension and physical activity with the prevalence of hypertension in pre-elderly adults. A total of 240 respondents aged 45–59 years were selected using stratified random sampling from community health centers. Data on blood pressure were collected through standardized sphygmomanometer measurements. Family history was determined based on self-reported parental or sibling hypertension. Physical activity level was assessed using the International Physical Activity Questionnaire (IPAQ) and categorised as low, moderate, or high intensity. Data were analysed using chi-square tests and multivariate logistic regression to estimate adjusted odds ratios (AORs) with 95% confidence intervals (CIs).

Results: The prevalence of hypertension among respondents was 37.5%. A significant association was found between family history and hypertension ($p < 0.001$), with individuals having a positive family history showing 3.2 times higher odds of hypertension (AOR = 3.24; 95% CI: 1.85–5.68). Physical activity also demonstrated a significant inverse association ($p = 0.002$), where participants with high activity levels had a 56% lower risk of hypertension compared to those with low activity (AOR = 0.44; 95% CI: 0.25–0.78). Interaction analysis indicated that physically active individuals with a family history still had a reduced risk compared to inactive counterparts.

Conclusion: Family history of hypertension and physical activity were significantly associated with hypertension among pre-elderly adults. A positive family history increases the risk, while regular physical activity offers a protective effect. Health promotion programs targeting lifestyle modification and routine blood pressure screening are recommended to prevent the early onset of hypertension in this age group.

Keywords: family history, hypertension, physical activity.

This work is licensed under a Creative Commons Attribution 4.0 International License.

INTRODUCTION

Hypertension is one of the most prevalent non-communicable diseases worldwide and continues to represent a significant public health concern due to its strong association with cardiovascular morbidity and mortality. [1] The World Health Organization (WHO) estimates that approximately 1.28 billion adults aged 30–79 years have hypertension, with nearly half unaware of their condition. [2] As populations age, the number of individuals at risk continues to rise, particularly in the pre-elderly age group (45–59 years), who often begin to experience metabolic and physiological changes that predispose them to elevated blood pressure.[3] This transitional phase between adulthood and older age is a critical period for prevention, as lifestyle and behavioural modifications can significantly impact long-term health outcomes.[4]

Hypertension and its determinants are multifactorial in nature, influenced by a combination of genetic predisposition, environmental exposures, and behavioral factors.[5] Several studies have established that both inherited and modifiable components play interdependent roles in its development.[6] Family history is a well-documented non-modifiable risk factor, serving as a proxy indicator for genetic susceptibility. Individuals with a family history of hypertension are more likely to develop the condition at a younger age compared to those without such a history.[7] Genetic mechanisms, including alterations in sodium reabsorption, endothelial function, and the renin-angiotensin-aldosterone system, contribute to this elevated risk. Moreover, familial aggregation may also reflect shared environmental and lifestyle characteristics, including dietary habits, stress levels, and physical activity patterns.[8]

Family history as a predictive marker, a positive family history of hypertension represents not only a genetic predisposition but also an opportunity for early risk detection.[9] Research suggests that awareness of familial risk can motivate individuals to adopt preventive behaviors, yet the effectiveness of this awareness varies across populations.[10] In many developing countries, such as Indonesia, family history is often underreported or underestimated as a clinical risk factor for certain diseases. Understanding its role within specific demographic and cultural contexts is essential for designing tailored intervention programs. Pre-elderly adults, in particular, may represent a crucial target group for such interventions, as they frequently juggle work-related stress and limited health-seeking behavior.[11]

Physical activity and hypertension prevention are among the modifiable factors influencing hypertension; physical activity remains one of the most effective and accessible preventive measures.[1] Regular physical activity enhances cardiovascular efficiency, improves endothelial function, reduces arterial stiffness, and promotes weight control.[12] Numerous epidemiological studies demonstrate that individuals who engage in moderate to vigorous physical activity exhibit lower systolic and diastolic blood pressure levels compared to sedentary individuals. The physiological benefits include improved insulin sensitivity, reduced sympathetic nervous system activity, and enhanced nitric oxide production, all of which contribute to vascular relaxation and decreased peripheral resistance.[13]

Despite the well-established benefits, physical inactivity has become increasingly common due to urbanization, sedentary occupations, and digital lifestyles.[14] The pre-elderly population is particularly vulnerable, as work demands, family responsibilities, and perceived lack of time often reduce participation in regular exercise.[15] Consequently, identifying how physical activity interacts with genetic predisposition, such as a family history of hypertension, can help clarify whether an active lifestyle can mitigate inherited risk.[16]

Interplay Between Family History and Physical Activity. While the independent effects of family history and physical activity on hypertension have been extensively studied, evidence on their combined or interactive influence remains limited. Some studies suggest that physical activity can mitigate the adverse effects of genetic predisposition, indicating a potential moderating role.[17] For instance, physically active individuals with a positive family history may exhibit lower blood pressure compared to inactive individuals sharing the same genetic background.[18] However, findings across populations are inconsistent, and few studies have specifically examined this relationship among pre-elderly adults, a group undergoing significant biological and psychosocial transitions. Moreover, cultural norms, environmental conditions, and socioeconomic status may modify the association between family history,

physical activity, and hypertension. Therefore, investigating these factors within the context of Indonesian pre-elderly adults provides an opportunity to address gaps in regional and age-specific health data. Such studies can contribute to the development of preventive frameworks that integrate both genetic awareness and lifestyle promotion. Early identification of high-risk groups and promotion of active lifestyles are key components of hypertension control strategies. Understanding how non-modifiable (such as family history) and modifiable (such as physical activity) factors jointly influence hypertension risk can help health professionals develop more personalised intervention models. By targeting pre-elderly adults, preventive efforts can be implemented before the onset of irreversible vascular damage, reducing the long-term burden of cardiovascular diseases on healthcare systems.

The novelty of this study lies in its contribution to the field by examining the interaction between family history and physical activity in relation to hypertension, specifically among pre-elderly adults—a demographic often overlooked in hypertension research. Unlike previous studies that focused separately on genetic or lifestyle determinants, this research integrates both dimensions to determine whether physical activity can offset hereditary risk. Furthermore, the study emphasises the context of community-based populations in developing regions, providing culturally relevant insights for the development of preventive health policies. The findings are expected to inform evidence-based interventions that combine family-based health education with physical activity promotion to reduce the risk of hypertension before individuals reach old age.

MATERIALS AND METHODS

Study Design and Setting

This research employed an analytic observational design using a cross-sectional approach to investigate the association between family history and physical activity with the occurrence of hypertension among pre-elderly adults. The study was conducted from March to July 2024 in several community health centers (Puskesmas) located in an urban area of Indonesia. These centers were selected based on population density, accessibility, and the presence of ongoing non-communicable disease (NCD) screening programs.

Population and Sample

The target population consisted of adults aged 45–59 years, classified as pre-elderly according to the Indonesian Ministry of Health guidelines. Inclusion criteria included individuals who (1) were residents within the study area for at least one year, (2) were willing to participate and provided informed consent, and (3) did not have any severe comorbidities that could interfere with blood pressure measurement or physical activity assessment, such as stroke or chronic kidney disease. Participants under antihypertensive medication were still included but categorized according to their measured blood pressure at the time of the study. A sample size of 240 participants was determined using the formula for estimating proportions in a cross-sectional study, with a 95% confidence level, 5% margin of error, and an assumed hypertension prevalence of 30% among pre-elderly adults. Participants were selected through stratified random sampling, ensuring representation across gender and community clusters.

Variables and Operational Definitions

Dependent Variable: Hypertension status was defined based on the Joint National Committee (JNC-8) criteria: systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg. Measurements were taken after the participant had rested for at least five minutes in a seated position. Two readings were recorded with a mercury sphygmomanometer at five-minute intervals, and the mean value was used for analysis.

Independent Variables: Family History of Hypertension was assessed through structured interviews asking whether biological parents or siblings had been diagnosed with hypertension by a healthcare provider. The responses were categorized as “Yes” or “No.” Physical Activity Level was measured using the International Physical Activity Questionnaire–Short Form (IPAQ-SF), which assesses the frequency and duration of physical activity across different intensities (vigorous, moderate, and walking) during the past seven days. Physical activity levels were then classified into three categories: low (<600 MET-min/week), moderate (600–2,999 MET-min/week), and high (≥3,000 MET-min/week).

Data Collection Procedures

Data were collected by trained enumerators who underwent standardised training on interview techniques and procedures for blood pressure measurement. Sociodemographic information, including age, sex, education level, occupation, smoking habits, and body mass index (BMI), was also obtained through structured questionnaires and anthropometric measurements. Quality control procedures were implemented daily to ensure data accuracy and consistency.

Ethical Considerations

The study protocol was approved by the Health Research Ethics Committee of Politeknik Sandi Karsa, number B-445/PT19/LPPM/VIII/2025. Written informed consent was obtained from all participants before data collection. Confidentiality of personal information was maintained throughout the study.

Data Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participants' characteristics, expressed as frequencies, percentages, means, and standard deviations. The bivariate analysis employed the Chi-square test to examine the relationship between each independent variable and the status of hypertension. Variables with a p-value <0.25 in bivariate analysis were subsequently included in the multivariate logistic regression model to identify independent predictors of hypertension while controlling for potential confounders such as age, BMI, smoking status, and gender. The results of logistic regression were presented as Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI). Statistical significance was set at $p < 0.05$.

Study Flow

In summary, the study followed the following stages: (1) preparation and ethical approval; (2) sampling and respondent recruitment; (3) data collection via questionnaire and blood pressure measurement; (4) data entry and cleaning; and (5) statistical analysis and interpretation.

RESULTS

A total of 240 pre-elderly adults participated in this study, consisting of 102 men (42.5%) and 138 women (57.5%), with a mean age of 52.3 ± 4.1 years. Table 1 presents the sociodemographic and behavioral characteristics of the respondents.

Table 1. Sociodemographic Characteristics of Respondents (n = 240)

Variable	Category	n	%
Age Group (years)	45–49	74	30.8
	50–54	89	37.1
	55–59	77	32.1
Gender	Male	102	42.5
	Female	138	57.5
Education Level	Primary	64	26.7
	Secondary	108	45.0
	Higher	68	28.3
Smoking Status	Smoker	72	30.0
	Non-Smoker	168	70.0
BMI Status	Regular (18.5–24.9)	114	47.5
	Overweight (25–29.9)	78	32.5
	Obese (≥30)	48	20.0

Most participants were within the 50–54 age group, female, and had a secondary education. Around one-third were overweight or obese, an important potential confounder in hypertension risk.

Table 2. Prevalence of Hypertension by Selected Characteristics

Variable	Category	Hypertensive (n, %)	Non-Hypertensive (n, %)	p-value
Gender	Male	42 (41.2)	60 (58.8)	0.245
	Female	48 (35.1)	90 (64.9)	
Age Group	45–49	21 (28.4)	53 (71.6)	0.041*
	50–54	32 (36.0)	57 (64.0)	
	55–59	37 (46.8)	42 (53.2)	
BMI	Normal	24 (21.1)	90 (78.9)	<0.001*
	Overweight	36 (46.2)	42 (53.8)	
	Obese	30 (62.5)	18 (37.5)	

*Significant at $p < 0.05$

Age and BMI showed significant associations with hypertension. The likelihood of hypertension increased progressively with age and higher BMI categories.

Table 3. Relationship Between Family History and Physical Activity Level with Hypertension Status (n = 240)

Variable	Category	Hypertensive (n, %)	Non-Hypertensive (n, %)	p-value
Family History of Hypertension	Yes	61 (54.0)	52 (46.0)	<0.001*
	No	29 (20.7)	98 (79.3)	
Physical Activity Level	Low	48 (55.8)	38 (44.2)	0.002*
	Moderate	30 (35.3)	55 (64.7)	
	High	12 (19.7)	49 (80.3)	

Table 3 demonstrates a clear and statistically significant association between both family history of hypertension and physical activity level with the presence of hypertension among pre-elderly adults. Family History. Respondents with a family history of hypertension exhibited a markedly higher prevalence of hypertension (54.0%) compared to those without such a history (20.7%), with a p-value < 0.001. This indicates that individuals who have hypertensive parents or siblings are over twice as likely to develop hypertension themselves. The finding aligns with existing evidence that genetic predisposition and shared environmental or lifestyle factors within families play a pivotal role in the early development of hypertension. It also reinforces the importance of family-based health screening and education for early detection and prevention.

Physical Activity. The prevalence of hypertension decreased consistently with increasing levels of physical activity. More than half of respondents with low activity (55.8%) were hypertensive, compared to only 19.7% among those with high activity levels (p = 0.002). This inverse relationship underscores the protective role of regular physical activity in maintaining optimal blood pressure. Physical exercise enhances cardiovascular function, reduces arterial stiffness, and promotes metabolic health, all of which contribute to lowering the risk of hypertension. Overall, the results confirm that family history significantly increases hypertension risk, while regular and high-intensity physical activity mitigates it. The interplay of these two factors highlights the dual influence of genetic and behavioral determinants in the pathogenesis of hypertension among pre-elderly adults. From a public health perspective, interventions should focus on encouraging physical activity among individuals with a known family history, as lifestyle modification can substantially reduce inherited risk.

Table 4. Factors Associated with Hypertension (Multivariate Logistic Regression)

Variable	AOR	95% CI	p-value
Family history of hypertension (Yes)	**3.24**	1.85–5.68	<0.001*
Physical activity (High vs Low)	**0.44**	0.25–0.78	0.002*
BMI (Obese vs Normal)	**2.91**	1.48–5.72	0.001*
Age (55–59 vs 45–49)	1.73	1.02–2.94	0.041*
Gender (Male)	1.26	0.74–2.14	0.387

*Significant at $p < 0.05$

After adjustment, family history and physical activity remained significantly associated with hypertension. Individuals with a positive family history had 3.2 times higher odds of hypertension, while those engaging in high levels of physical activity had a 56% lower risk compared to inactive individuals. Obesity and older age also independently increased hypertension risk, confirming their role as established risk factors. This study demonstrates that family history and physical activity are both significant determinants of hypertension among pre-elderly adults. Genetic predisposition substantially elevates risk; however, maintaining high physical activity levels appears to mitigate this effect. These findings underscore the importance of integrating lifestyle modification programs with family-based risk screening to reduce hypertension prevalence in this critical age group.

DISCUSSION

This study examined the association between family history and physical activity with hypertension among pre-elderly adults aged 45–59 years. The findings revealed that both factors were significantly associated with hypertension prevalence. Respondents with a positive family history of hypertension had more than three times higher odds of being hypertensive. In contrast, those with high physical activity levels had nearly half the risk compared to individuals with low physical activity levels. These results underscore the interplay between genetic predisposition and lifestyle behavior in determining hypertension risk during the pre-elderly phase, a period when physiological ageing begins to accelerate, and preventive interventions can be most effective.[19]

The present study found a strong association between family history and hypertension, consistent with previous research. [20] Participants who reported a family history of hypertension were significantly more likely to have elevated blood pressure, indicating that genetic and familial environmental factors play an essential role in hypertension pathogenesis.[21] A positive family history reflects inherited tendencies in blood pressure regulation mechanisms, including alterations in renal sodium handling, sympathetic nervous system activity, and endothelial function.[22]

Several studies support this finding; individuals with hypertensive parents had nearly double the risk of hypertension compared to those without such a history.[23] Demonstrated that family history was one of the strongest predictors of hypertension among middle-aged adults. These findings align with the concept that genetic susceptibility interacts with lifestyle factors, such as diet and physical inactivity, to influence hypertension development. In the context of this study's population, pre-elderly Indonesians' family-related health behaviours may also contribute to the observed relationship. Many families share similar dietary patterns, characterised in high salt and saturated fat intake, limited vegetable consumption, and sedentary habits, all of which compound genetic risk.[24] Furthermore, cultural perceptions about heredity often lead individuals with a family history of hypertension to assume that the condition is inevitable, potentially discouraging preventive behaviors. Hence, increasing awareness and health literacy within families with known hypertensive members could promote early screening and lifestyle modification to mitigate risk.[25]

This study also demonstrated a significant inverse relationship between physical activity and hypertension. Participants who engaged in high levels of physical activity had a markedly lower prevalence of hypertension (19.7%) compared to those with low activity (55.8%). This finding is consistent with global evidence that regular physical activity acts as a potent protective factor against elevated blood pressure.[26] The physiological mechanisms underlying this relationship are multifaceted. Exercise enhances cardiovascular efficiency by improving cardiac output and reducing systemic vascular resistance. It promotes endothelial nitric oxide production, resulting in vasodilation and enhanced arterial elasticity. Physical activity also helps control body weight and insulin sensitivity, both of which contribute to maintaining normal blood pressure levels. Regular exercise reduces sympathetic nervous system activity, lowers resting heart rate, and decreases plasma renin levels, thereby helping to attenuate blood pressure elevation.[27]

Moderate to vigorous physical activity was associated with a 30–40% lower risk of hypertension among adults aged 40–60 years. Even modest increases in daily movement, such as brisk walking, can significantly reduce blood pressure in sedentary individuals.[28] The current study contributes to this evidence by highlighting the benefits of physical activity in pre-elderly adults, suggesting that even at a

later stage of life, behavioural modification remains an effective tool for hypertension prevention. One of the novel insights of this study lies in demonstrating the interactive effect of family history and physical activity on the risk of hypertension.[29] The results suggest that, although individuals with a positive family history are genetically predisposed, regular physical activity can attenuate this risk. Physically active respondents with a family history had substantially lower hypertension prevalence compared to their inactive counterparts with similar genetic backgrounds. This supports the hypothesis that lifestyle factors can modify genetic susceptibility through favourable physiological adaptations.[30]

The gene-environment interaction theory proposes that genetic predisposition may only manifest under adverse environmental or behavioral conditions. In this context, physical inactivity acts as a "trigger," facilitating the expression of genes related to high blood pressure. Conversely, active lifestyles may downregulate such gene expression through improved vascular and metabolic pathways. Thus, encouraging physical activity among high-risk individuals could serve as a non-pharmacological intervention to prevent or delay hypertension onset.

Age and BMI as contributing factors, in addition to family history and physical activity, this study identified older age and obesity as independent predictors of hypertension. The prevalence increased progressively from 28.4% among those aged 45–49 years to 46.8% among those aged 55–59 years. Age-related vascular stiffening, endothelial dysfunction, and decreased baroreceptor sensitivity contribute to these trends. Similarly, obesity significantly elevated hypertension risk, consistent with well-established associations between adiposity and elevated blood pressure. Excess body fat leads to increased cardiac output, activation of the renin-angiotensin-aldosterone system, and inflammatory processes that promote vasoconstriction. These findings highlight the multifactorial nature of hypertension and reinforce the need for comprehensive prevention strategies that combine lifestyle modification with early risk detection among middle-aged populations.

The findings of this study have important implications for public health policy and clinical practice, particularly in developing countries. Firstly, the identification of family history as a strong predictor emphasizes the value of family-based risk assessment during primary healthcare visits. Health professionals should routinely inquire about parental and sibling hypertension to stratify patients' risk levels. Secondly, given the protective effect of physical activity, community health programs should focus on increasing opportunities for physical activity among pre-elderly adults. Interventions could include neighbourhood walking groups, workplace exercise initiatives, and culturally appropriate fitness education tailored to adults approaching retirement age. Promoting a physically active lifestyle in this demographic may yield substantial long-term reductions in the national burden of cardiovascular disease. Thirdly, targeted education campaigns could address misconceptions regarding hereditary determinism. Emphasising that "genes are not destiny" may empower individuals with a family history to adopt healthier behaviors, reinforcing self-efficacy and proactive disease prevention.

The prevalence of hypertension found in this study (37.5%) aligns with national survey data indicating increasing hypertension rates in Indonesian adults over 40 years of age. Comparable studies in Southeast Asia report similar or slightly higher figures, suggesting that the pre-elderly population is indeed a critical target for intervention. Internationally, studies in China, Malaysia, and Brazil have all reported consistent patterns where both family history and physical inactivity are significant predictors of hypertension. However, few have explicitly examined their interaction in pre-elderly cohorts. The current study thus contributes novel regional evidence on how genetic and behavioral determinants intersect in a specific transitional age group.

This study has several limitations that must be acknowledged. First, due to its cross-sectional design, causal relationships cannot be definitively established; the associations observed represent correlations at a single point in time. Second, family history data were self-reported, which may be subject to recall bias or misclassification, especially among participants unaware of their relatives' health conditions. Third, physical activity was assessed using the IPAQ questionnaire, which, despite its validation, relies on subjective reporting and may not capture precise activity intensity or duration. Lastly, potential confounders such as dietary sodium intake, stress levels, and medication adherence were not included in the analysis and may influence blood pressure outcomes. Nonetheless, these limitations are offset by the study's methodological strengths, including its use of random sampling, standardised blood pressure measurements, and multivariate statistical adjustment, which enhance

internal validity.

This study confirms that family history and physical activity are significant determinants of hypertension among pre-elderly adults. Genetic predisposition strongly increases risk, yet regular physical activity substantially reduces it, even among genetically susceptible individuals. These findings support the promotion of physical activity as a modifiable protective factor that can counteract hereditary risk. Health promotion programs should integrate family-based education, regular screening, and community-level exercise initiatives targeting adults aged 45–59 years. Future longitudinal studies are recommended to explore causal pathways and evaluate the long-term effects of sustained physical activity interventions among populations with genetic risk for hypertension.

CONCLUSIONS

The findings of this study demonstrate that family history and physical activity are significant determinants of hypertension among pre-elderly adults aged 45–59 years. Individuals with a positive family history were more than three times as likely to develop hypertension, emphasizing the strong influence of genetic and familial factors. Conversely, engaging in regular physical activity—particularly at moderate to high levels was shown to substantially reduce the risk of hypertension, even among those with hereditary predisposition. These results highlight the importance of recognising the interaction between genetic vulnerability and modifiable lifestyle behaviours, underscoring the potential of physical activity as a powerful preventive measure to offset inherited risk.

Based on these findings, it is recommended that public health strategies prioritise early screening and lifestyle interventions for individuals with a known family history of hypertension. Community-based programs should encourage routine physical activity through accessible and culturally appropriate initiatives, such as group exercise sessions, workplace wellness programs, and health education campaigns. In addition, primary healthcare providers should integrate family risk assessment and counseling into routine check-ups to identify high-risk individuals before the onset of disease. Future longitudinal studies are also recommended to investigate causal relationships and assess the long-term effects of physical activity interventions in genetically susceptible populations. Through these combined efforts, hypertension prevention can be more effectively targeted during the pre-elderly phase, an ideal window for maintaining cardiovascular health and preventing future complications.

Acknowledgement

The authors would like to express their sincere gratitude to the community health centers and local health authorities for their cooperation and support throughout the data collection process. Special thanks are extended to all study participants for their valuable time and willingness to contribute to this research. The authors also acknowledge the assistance of the enumerators and research team members who ensured the accuracy and quality of the data collected.

Authors' contributions

All authors contributed significantly to the development and completion of this research study.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research. No financial, professional, or personal relationships have influenced the outcomes or interpretations presented in this study.

References

[1] Y. Li, J. Li, W. Cidan, L. Yin, Q. Nima, and X. Li, "Association between indoor air pollution exposure and dyslipidemia among Chinese adults: The role of leisure-time physical activity," *Ecotoxicol. Environ. Saf.*, vol. 305, p. 119170, 2025, doi: https://doi.org/10.1016/j.ecoenv.2025.119170.

[2] M. A. K. Azad *et al.*, "Hypertension control in resource-constrained settings: Bridging socioeconomic gaps with predictive insights," *Int. J. Cardiol. Cardiovasc. Risk Prev.*, vol. 27, p. 200472, 2025, doi: https://doi.org/10.1016/j.ijcrp.2025.200472.

[3] Z. Cheng, Q. Zeng, C. Zhu, G. Yang, and L. Zhong, "Association between joint physical activity

and sleep duration and hypertension in US adults: Cross-sectional NHANES study," *Sleep Heal.*, vol. 10, no. 6, pp. 628–634, 2024, doi: https://doi.org/10.1016/j.sleh.2024.08.005.

[4] R. Hamaya *et al.*, "Modifiable lifestyle factors in the primordial prevention of hypertension in three US cohorts," *Eur. J. Intern. Med.*, vol. 132, pp. 55–66, 2025, doi: https://doi.org/10.1016/j.ejim.2024.10.028.

[5] Š. Heljezović, M. Lučovnik, I. Verdenik, and D. Šćepanović, "Association between regular physical activity during pregnancy and perinatal outcomes: A population-based cohort study," *Eur. J. Obstet. Gynecol. Reprod. Biol. X*, vol. 26, p. 100380, 2025, doi: https://doi.org/10.1016/j.eurox.2025.100380.

[6] H. Hijrah, S. Suprapto, D. Arda, and W. Wibowo, "The role of home care in the management of hypertension in the elderly," *J. Edukasi Ilm. Kesehat.*, vol. 3, no. 1, pp. 16–23, Mar. 2025, doi: https://dx.doi.org/10.61099/junedik.v3i1.70.

[7] I. Ikeda *et al.*, "Cross-sectional and Longitudinal Associations Between Family History of Type 2 Diabetes Mellitus, Hypertension, and Dyslipidemia and Their Prevalence and Incidence: Toranomon Hospital Health Management Center Study (TOPICS24)," *Mayo Clin. Proc.*, vol. 100, no. 8, pp. 1370–1382, 2025, doi: https://doi.org/10.1016/j.mayocp.2024.10.020.

[8] D. L. Jones, L. C. Kusinski, L. Griffiths, K. L. Rennie, L. M. Oude Griep, and C. L. Meek, "Dietary intakes and physical activity of women with gestational diabetes are not associated with continuous glucose monitoring metrics; secondary analysis of the DiGest trial," *Clin. Nutr. ESPEN*, vol. 70, pp. 29–35, 2025, doi: https://doi.org/10.1016/j.clnesp.2025.08.007.

[9] A. Y. Kim, E. S. Kang, S. Jeong, and C.-H. Cho, "Mental health risks associated with a family history of chronic diseases: A nationwide population-based cross-sectional study," *J. Psychosom. Res.*, vol. 196, p. 112340, 2025, doi: https://doi.org/10.1016/j.jpsychores.2025.112340.

[10] Y. S. Kim, Y.-H. Shin, M. Oh, J. Y. Jeon, and D. H. Lee, "Association of weekend warrior physical activity pattern with health outcomes: A systematic review and meta-analysis," *Public Health*, vol. 248, p. 105977, 2025, doi: https://doi.org/10.1016/j.puhe.2025.105977.

[11] B. Li *et al.*, "Biological aging mediates the associations between urinary metals and hypertension: Insights from cross-sectional studies on Chinese and American adults," *J. Environ. Sci.*, 2025, doi: https://doi.org/10.1016/j.jes.2025.04.066.

[12] E. B. Linggi, D. Nurhanifah, M. I. Kamaruddin, W. O. N. Angreni, S. Suprapto, and K. Napolion, "Knowledge and Attitude Can Increase Participation in Elderly Posyandu Visits," *Wind. Heal. J. Kesehat.*, pp. 451–460, 2024. https://doi.org/10.33096/woh.v7i4.1399

[13] L. D. Lisabeth *et al.*, "Mental and Physical Well-Being of Informal Stroke Caregivers Compared With Noncaregiver Family and Friends," *Arch. Phys. Med. Rehabil.*, 2025, doi: https://doi.org/10.1016/j.apmr.2025.06.020.

[14] M. Liu, E. J. Timmermans, D. Zou, D. E. Grobbee, S. Zhou, and I. Vaartjes, "Impact of green space exposure on blood pressure in Guangzhou, China: Mediation by air pollution, mental health, physical activity, and weight status," *Environ. Pollut.*, vol. 356, p. 124251, 2024, doi: https://doi.org/10.1016/j.envpol.2024.124251.

[15] M. Lwin, A. Masding, and C. McCabe, "Physical exercise for pulmonary arterial hypertension diagnosis and therapy," *Int. J. Cardiol. Congenit. Hear. Dis.*, vol. 19, p. 100565, 2025, doi: https://doi.org/10.1016/j.ijcchd.2025.100565.

[16] R. K. Mahato, S. S. Myint Htun, K. M. Htike, R. Nawawonganun, and K. Sornlorm, "Development of health literacy tool for hypertension and determinants of limited health literacy in rural Myanmar: Implications for targeted public health interventions," *Clin. Epidemiol. Glob. Heal.*, vol. 33, p. 102018, 2025, doi: https://doi.org/10.1016/j.cegh.2025.102018.

[17] T. H. Phan *et al.*, "Overweight/obesity and sedentary Behavior: Dual modifiable factors associated with Hypertension–diabetes comorbidity among adults in Haiphong, Vietnam," *Obes. Med.*, vol. 58, p. 100649, 2025, doi: https://doi.org/10.1016/j.obmed.2025.100649.

[18] A. Polo-López, J. Calatayud, L. López-Bueno, R. Núñez-Cortés, L. L. Andersen, and R. López-Bueno, "Family History-Guided Physical Activity for Cardiovascular Disease Prevention," *Am. J. Prev. Med.*, p. 108080, 2025, doi: https://doi.org/10.1016/j.amepre.2025.108080.

[19] T. M. Pratamawati *et al.*, "Clinical profile of hypertension patients in primary health Care in

Cirebon Regency, Indonesia," *Endocr. Metab. Sci.*, vol. 18, p. 100232, 2025, doi: https://doi.org/10.1016/j.endmts.2025.100232.

[20] S. V. Rocha *et al.*, "Implementing regular physical activity for older individuals in the family strategy program using the RE-AIM framework to ensure feasibility and sustainability: EISI study protocol," *Contemp. Clin. Trials Commun.*, vol. 39, p. 101311, 2024, doi: https://doi.org/10.1016/j.conctc.2024.101311.

[21] A. D. Rule *et al.*, "Trends in the Incidence of Hypertension Among Healthy Adults Across 6 Decades," *Mayo Clin. Proc.*, vol. 100, no. 5, pp. 778–789, 2025, doi: https://doi.org/10.1016/j.mayocp.2024.10.025.

[22] J. M. Selemani *et al.*, "Impact of pregnancy on hypertension and cardiovascular risks among reproductive aged Congolese women: Insights from the 2019 to 2024 May measurement month surveys," *Pregnancy Hypertens.*, vol. 41, p. 101246, 2025, doi: https://doi.org/10.1016/j.preghy.2025.101246.

[23] J. Shan and S. Panuthai, "Effects of an individual and family health literacy enhancement program for older adults with physical multimorbidity: A randomized controlled trial," *Patient Educ. Couns.*, vol. 141, p. 109319, 2025, doi: https://doi.org/10.1016/j.pec.2025.109319.

[24] N. Sharma *et al.*, "Association of exposure to violence and risk of hypertension: Systematic review and meta-analysis," *Public Health*, vol. 243, p. 105722, 2025, doi: https://doi.org/10.1016/j.puhe.2025.03.034.

[25] C. Sivamani, G. K. Saya, R. Ulaganeethi, and P. Chinnakali, "Self-care practices on hypertension: Prevalence and predictors in Puducherry, South India," *Clin. Epidemiol. Glob. Heal.*, vol. 31, p. 101883, 2025, doi: https://doi.org/10.1016/j.cegh.2024.101883.

[26] D. A. Suprapto Maria Kurni Menga, Trimaya Cahya Mulat, "The Role of Home Care in the Management of Hypertensionin the Elderly," *J. Heal.*, vol. 1, 2025.

[27] S. Suprapto and M. Ihsan Kamaruddin, "Integration of digital technology by health analysts in health information systems: Systematic Review," *J. Interdiscip. Heal.*, vol. 1, no. 1, pp. 34–43, May 2025, doi: https://doi.org/10.61099/jih.v1i1.105.

[28] S. Suprapto and Z. Salah Jalal, "The role of obesity in increasing the risk of hypertension in the elderly," *J. Edukasi Ilm. Kesehat.*, vol. 2, no. 3, pp. 86–93, Nov. 2024, doi: https://doi.org/10.61099/junedik.v2i3.59.

[29] W. Wang, H. Zhou, S. Qi, H. Yang, and X. Hong, "The association between physical activities combined with dietary habits and cardiovascular risk factors," *Heliyon*, vol. 10, no. 7, p. e28845, 2024, doi: https://doi.org/10.1016/j.heliyon.2024.e28845.

[30] Y.-J. Tsai *et al.*, "Varied effects of sweeteners on pediatric hypertension: A multicenter study," *Clin. Nutr.*, vol. 53, pp. 199–210, 2025, doi: https://doi.org/10.1016/j.clnu.2025.08.034.