The Relationship between Lifestyle and Individual Factors with Blood Pressure Control in Hypertension Patients of Productive Age at the Caringin Community Health Center, Tangerang Regency

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Abstract

Hypertension is one of the non-communicable diseases that poses a major health problem in Indonesia, especially among the productive age group. This study aims to examine the relationship between lifestyle patterns and individual factors with blood pressure control in hypertensive patients of productive age at Caringin Public Health Center, Tangerang Regency. The variables studied include personal health history, family history, age, gender, excessive salt consumption, excessive sugar consumption, excessive fat consumption, alcohol consumption, smoking, consumption of vegetables and fruits, physical activity, blood glucose levels, and obesity. The study used a retrospective design with a quantitative approach and a sample of 310 respondents. The results showed a significant association between age, excessive salt consumption, alcohol consumption, consumption of vegetables and fruits, family history of hypertension, smoking habits, and lack of physical activity with increased blood pressure in hypertensive patients. However, personal health history did not show a significant association with blood pressure ($p = 0.169$). Multivariate analysis identified productive age, excessive salt consumption, consumption of vegetables and fruits, family history of hypertension, excessive fat consumption, lack of physical activity, and personal health history as candidate factors contributing to increased blood pressure.

Keywords: Physical Activity, Hypertension, Productive Age

Introduction

Hypertension is one of the most important public health problems in the world and a major cause of cardiovascular mortality such as coronary heart disease, stroke, and chronic kidney disease [1]. The burden of disease due to hypertension remains high: many people are unaware of their condition, and the achievement of blood pressure control in the general population is still far from ideal, increasing the risk of long-term complications. Efforts to prevent and control hypertension require a combination of pharmacological interventions and sustained lifestyle changes[2].

National health surveys in Indonesia indicate that the prevalence of hypertension tends to increase in recent years, especially among the adult age group. This increase is accompanied by a still low proportion of hypertension patients who are diagnosed and receiving regular treatment, let alone those who successfully achieve optimal blood pressure control. Primary services (Community Health Centers and community-based programs) play a central role in early detection, management, and education for patients. Various programs have been implemented, ranging from screening at community health posts, empowering health cadres, to strengthening non-communicable disease (NCD) management [3]. However, hypertension control achievements are not evenly distributed across regions, thus contextual studies at the local level are needed to understand the factors affecting successful blood pressure control.

The concept of productive age (generally 15–64 years) becomes important because hypertension in this group has significant socio-economic impacts — reducing work productivity, increasing healthcare costs, and affecting family well-being. The productive age group often has lifestyle patterns influenced by work demands, practical eating habits, work-related stress, and fluctuating adherence to medication. Recent studies show that hypertension is increasingly found at younger ages, even below 40 years, which were previously considered relatively safe from cardiovascular risk. This makes research focusing on the productive age highly relevant, both for prevention and control purposes [4].

Lifestyle includes habits such as salt consumption, dietary patterns (for example, adherence to the Dietary Approaches to Stop Hypertension or DASH), physical activity, smoking habits, alcohol consumption, weight management, sleep patterns, and the ability to manage stress [5]. Scientific evidence indicates that lifestyle modifications such as reducing sodium intake, increasing consumption of fruits and vegetables, maintaining an ideal weight, engaging in regular physical activity, and quitting smoking can lower systolic blood pressure by 5–10 mmHg and reduce the risk of cardiovascular events. These interventions are effective both as prevention and as supportive therapy for patients using antihypertensive medications. Identifying the lifestyle components that most influence successful blood pressure control is a strategic step in designing community health center (Puskesmas)-based interventions [6].

Individual factors such as age, gender, body mass index (BMI), education level, employment status, medication adherence, the presence of comorbidities (such as diabetes or kidney disease), psychosocial stress levels, and access to healthcare services also influence the success of hypertension control. Adherence to medication and regular visits to primary care are reported as strong predictors of achieving blood pressure targets. Conversely, patients who are non-adherent or rarely attend check-ups tend to have a higher risk of uncontrolled blood pressure and complications. Understanding the relationship between these factors is crucial so that control strategies can be tailored to the patient's condition and characteristics [4] [7].

In the context of healthcare services in Indonesia, community health centers (Puskesmas) play a key role in early detection, education, therapy monitoring, and referral of hypertensive patients. Hypertension control programs at Puskesmas involve community screening activities, nutrition counseling, recommendations for physical activity, and medication therapy. However, the effectiveness of these programs is influenced by various factors such as healthcare workforce capacity, patient adherence, family support, and local socioeconomic conditions. Research in various regions shows variations in success, making local data-based evaluation essential to ensure that interventions are designed according to community needs [6].

The working area of the Caringin Community Health Center in Tangerang Regency has limited specific data regarding lifestyle factors and individual characteristics that affect blood pressure control in hypertensive patients

of productive age. In fact, this area has socio-economic and cultural characteristics that can influence eating habits, physical activity, and medication adherence. Research exploring the relationship between lifestyle patterns and individual factors with blood pressure control in this area will provide a comprehensive overview and serve as a basis for designing more targeted interventions [8].

Based on the above explanation, research on the relationship between lifestyle patterns and individual factors with blood pressure control in productive-age hypertensive patients at Caringin Health Center in Tangerang Regency is important to conduct. The study results are expected to provide valuable input for healthcare workers, NCD program managers, and regional policymakers to increase the proportion of patients achieving optimal blood pressure control, reduce cardiovascular complication rates, and support the enhancement of community productivity.

Material and Methods.

This study employed a quantitative approach with a retrospective cohort design. This design was chosen because it is suitable for tracing the relationship between risk factors (lifestyle and individual factors) and blood pressure control outcomes based on previously documented data. Through this design, the researcher can identify variables that contribute to the success or failure of blood pressure control in hypertensive patients of productive age. All data used in this study were secondary data obtained from the Non-Communicable Disease Information System (SIPTM) and medical records of hypertensive patients at Caringin Community Health Center (Puskesmas) in Tangerang Regency.

The data collection period focused on May 2024, selected because it was the month with the most complete and updated hypertension records in SIPTM. Data analysis was conducted in June 2024 after all data had been collected and verified for completeness. Utilizing secondary data allowed for efficient research, as the SIPTM database already contains demographic information, lifestyle factors, medical history, blood pressure examination results, and other relevant health indicators.

The study population consisted of all hypertensive patients of productive age, between 15 and 64 years old, registered in the SIPTM database of Caringin Puskesmas in May 2024, including both new and existing patients. The study used a total sampling method, meaning all population members who met the inclusion criteria and did not meet the exclusion criteria were included as samples.

The inclusion criteria were established to ensure sample uniformity and data relevance to the study objectives, namely: (1) patients aged 15–64 years at the time of registration in SIPTM in May 2024; and (2) registered as hypertensive patients at Caringin Puskesmas, Tangerang Regency. The exclusion criteria consisted of incomplete patient data on variables to be analyzed. This exclusion was crucial, as incomplete data could reduce the validity of the results and hinder statistical analysis.

Data analysis was performed in stages. The first stage involved univariate analysis to describe the distribution of respondent characteristics, including both dependent and independent variables, presented as frequency and percentage. The second stage was bivariate analysis to examine the relationship between each independent variable (age, gender, excessive salt intake, excessive sugar intake, blood glucose levels, excessive fat intake, alcohol consumption, smoking habits, family history of hypertension, physical inactivity, insufficient fruit and vegetable consumption, obesity, and comorbidities) and the dependent variable (blood pressure control status) using the Chi-Square (χ^2) test. The significance level used was p-value < 0.05. The third stage was multivariate analysis using logistic regression to identify the most influential independent factors on blood pressure control after adjusting for

other variables. Variables with p-values < 0.25 in the bivariate analysis were included in the multivariate model. This approach helps reduce bias and produces a more accurate predictive model.

This study was conducted in accordance with ethical principles in health research. Although it did not involve direct contact with patients, confidentiality and data privacy were prioritized. Patients' personal identities were removed from all documents before analysis. Additionally, researchers obtained official approval from Caringin Puskesmas and the Tangerang Regency Health Office to access and utilize the necessary secondary data. Thus, the study complies with ethical standards and administrative procedures applicable in the healthcare facility.

Results and Discussion

The boxplot graph above presents the distribution of six directly measured variables in this study, namely usia, systolic and diastolic blood pressure, blood glucose levels, body mass index (BMI), and the waist circumference of respondents. This visualization shows the spread of values for each variable based on minimum value, first quartile (Q1), median (Q2), third quartile (Q3), up to the maximum value. The respondents' usia shows a relatively even distribution with an age range between 16 and 60 years and data concentrated in the productive age group. Systolic blood pressure exhibits considerable variation, with a maximum value reaching 213 mmHg and the third quartile at 140 mmHg, indicating that some respondents have blood pressure above the normal threshold. A similar pattern is observed in diastolic blood pressure, which has a median of 80.5 mmHg and a maximum of up to 118 mmHg, reflecting the presence of individuals with high diastolic blood pressure.

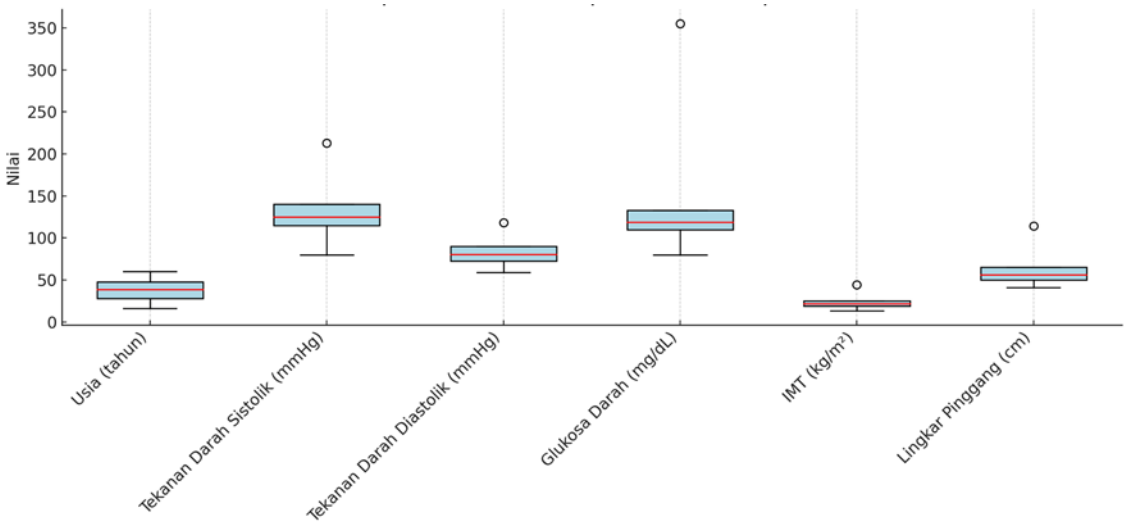

Figure 1. Distribution of Age Characteristics, Blood Pressure, Glucose Levels, BMI, and Waist Circumference in Productive Age Hypertension Patients at Caringin Health Center, Tangerang Regency

The distribution of blood glucose levels shows a very wide range, from 80 to 355 mg/dL, with the majority of respondents falling within values approaching the prediabetes to hyperglycemia threshold. This spread indicates variability in glucose control among respondents. Most respondents' body mass index falls within the normal nutrition status to mild overweight categories, although the maximum value reaches 44.1 kg/m², indicating

individuals with severe obesity. Waist circumference also exhibits wide variation, with a maximum value reaching 114 cm, suggesting the possibility of central obesity in a small portion of the population. Overall, this boxplot shows substantial variation especially in blood pressure and blood glucose levels, which implies diversity in the health status of respondents in this study.

Table 1. Overview of Lifestyle Patterns and Individual Factors Related to Blood Pressure Control in Productive-Age Hypertension Patients at Caringin Health Center, Tangerang Regency

Variable Name	n	%
Blood Pressure Control		
Uncontrolled	92	29,7
Controlled	218	70,3
Age Group		
40-64 years	149	48,1
<40 years	161	51,9
Gender		
Female	234	75,5
Male	76	24,5
Excessive Salt Consumption		
Yes	88	28,4
No	222	71,6
Excessive Sugar Consumption		
Yes	187	60,3
No	123	39,7
Blood Glucose Level		
Hyperglycemia	4	1,3
Normal	306	98,7
Obesity		
Yes	147	69,7
No	64	30,3
Excessive Fat Consumption		
Yes	132	42,6
No	178	57,4
Alcohol Consumption		
Yes	9	2,9
No	301	97,1
Low Fruit and Vegetable Intake		
Yes	156	50,3
No	154	49,7

Family History of Hypertension		
Present	86	27,7
Absent	224	72,3
Comorbidities		
Present	210	67,7
Absent	100	32,3
Smoking		
Yes	59	19
No	251	81
Physical Inactivity		
Yes	147	47,4
No	163	52,6

The results presented in the descriptive analysis show the frequency distribution of respondent characteristics based on several study variables (n = 310). Regarding blood pressure control, the majority of respondents had normal blood pressure, totaling 218 individuals (70.3%), while 92 (29.7%) were categorized as having uncontrolled hypertension. The age distribution was dominated by the group under 40 years old, with 161 respondents (51.9%), and 149 respondents (48.1%) in the 40–64 years age group. By gender, most respondents were female, accounting for 234 individuals (75.5%), while males numbered 76 (24.5%).

The consumption patterns showed that most respondents consumed less salt than recommended, with 222 individuals (71.6%), whereas 88 (28.4%) consumed excess salt. Conversely, regarding sugar intake, the majority of respondents were in the excess consumption category at 187 individuals (60.3%), with 123 (39.7%) consuming less. Blood glucose levels were normal in almost all respondents, 306 individuals (98.7%), with only 4 (1.3%) experiencing hyperglycemia. Nutritional status showed that most respondents were not obese, with 245 individuals (79.0%), while 65 (21.0%) were classified as obese. For fat consumption, the majority consumed less fat, totaling 178 individuals (57.4%), while 132 (42.6%) reported excess consumption.

Almost all respondents abstained from alcohol, with 301 individuals (97.1%) reporting no alcohol use, while 9 (2.9%) reported alcohol consumption. Fruit and vegetable intake was relatively balanced, with 156 individuals (50.3%) reporting low consumption and 154 (49.7%) reporting adequate intake. A family history of hypertension was absent in most respondents, 224 individuals (72.3%), while 86 (27.7%) had a positive family history.

The majority of respondents reported having comorbidities (such as diabetes, hypertension, or heart disease), totaling 210 individuals (67.7%), while 100 (32.3%) had no comorbidities. Regarding smoking behavior, most respondents did not smoke, with 282 individuals (91.0%), whereas 28 (9.0%) still smoked. Physical activity levels tended to be low, with 147 respondents (47.4%) reporting insufficient activity and 163 (52.6%) engaging in adequate physical activity.

These results indicate that although most respondents have normal blood pressure, risk factors such as excess sugar consumption, presence of comorbidities, and low physical activity remain fairly high. This pattern suggests that respondents are at risk of transitioning to other cardiometabolic diseases if these risk factors are not controlled. The high participation of females in this study may also reflect gender differences in health behavior and engagement

in health surveys. Overall, these findings highlight the need for healthy lifestyle interventions focused on controlling sugar intake, increasing physical activity, and managing comorbid conditions to prevent future cardiovascular complications.

Table 2. Results of the Test of the Relationship Between Risk Factors and Blood Pressure Control in Hypertensive Patients at Caringin Health Center, Tangerang Regency

Variable Name	blood pressure				Pvalue	PR	95 %CI
	Controlled		uncontrolled				
	n	%	n	%			
Age							
40-64 years	62	41,6	87	58,4	<0,001	3,11	1,86-5,19
< 40 years	30	18,6	131	81,4			
Gender							
Female	73	31,2	161	68,8	0,377	1,36	0,75-2,45
Male	19	25	57	75			
Obesity							
Yes	21	32,3	44	67,7	0,712	1,17	0,64-2,10
No	71	29	174	71			
Excessive Salt Consumption							
Yes	63	71,6	25	28,4	<0,001	16,77	9,15-
No	29	13,1	193	86,9			30,73
Excessive Sugar Consumption							
Yes	62	33,2	125	66,8	0,127	1,53	0,92-2,56
No	30	24,4	93	75,6			
Blood Glucose Level							
Hyperglycemia	2	50	2	50	0,371	2,40	0,33-
Normal	5	1,8	267	98,2			17,30
Excessive Fat Consumption							
Yes	58	32,6	120	67,4	0,240	1,39	0,84-2,29
No	34	25,8	98	74,2			
Alcohol Consumption							
Yes	7	77,8	2	22,2	0,001	8,89	1,81-
No	85	28,2	216	71,8			43,67
Low Fruit and Vegetable Intake							
Yes	82	52,6	74	47,4	<0,001	15,96	7,81-
No	10	6,5	144	93,5			32,58
Family History of Hypertension							
Present	69	80,9	17	19,8	<0,001	35,47	17,47-
Not Present	23	10,3	201	89,7			70,29
Smoking							

Variable Name	blood pressure				Pvalue	PR	95 %Cl
	Controlled		uncontrolled				
	n	%	n	%			
Yes	31	52,5	28	47,5	<0,001	3,45	1,92-6,20
No	61	24,3	190	75,5			
Physical Activity							
Yes	85	57,8	62	42,2	<0,001	30,55	13,39-
No	7	4,3	156	95,7			69,72
Complication Disease							
Present	68	32,4	142	67,6	0,169	1,52	0,88-2,61
Not Present	24	24	76	76			

The analysis of the relationship between age and blood pressure control showed that respondents aged 40–64 years had a higher prevalence of uncontrolled blood pressure (41.6%) compared to those under 40 years old (18.6%). Statistical tests confirmed a significant association ($p < 0.05$) with a Prevalence Ratio (PR) of 3.112. This means the 40–64 age group has more than three times the risk of uncontrolled blood pressure compared to the younger group.

Regarding gender, females had a higher prevalence of uncontrolled blood pressure (31.2%) than males (25%), but this difference was not statistically significant ($p \geq 0.05$), indicating gender is not a primary determinant of blood pressure control in this population.

Obesity showed a similar trend. Respondents classified as obese had a higher prevalence of uncontrolled blood pressure (32.3%) than non-obese respondents (29%), but statistical analysis indicated no significant association ($p \geq 0.05$).

A different pattern emerged with salt consumption. Respondents consuming excess salt exhibited a very high prevalence of uncontrolled blood pressure (71.6%) compared to those with low salt intake (13.1%). The analysis showed a significant relationship ($p < 0.05$) with a PR of 16.771 (95% CI: 9.151–30.737), confirming excessive salt intake as a key risk factor for uncontrolled blood pressure.

For sugar consumption, the prevalence of uncontrolled blood pressure was higher in the excessive intake group (33.2%) than in the low intake group (24.4%), although this was not statistically significant ($p \geq 0.05$). Similarly, fat consumption showed a higher prevalence in the excessive group (32.6%) than in the low group (25.8%), without a meaningful statistical association ($p \geq 0.05$).

Alcohol consumption showed a significant impact. Respondents who consumed alcohol had a much higher prevalence of uncontrolled blood pressure (77.8%) compared to non-drinkers (28.2%). Statistical testing demonstrated a significant relationship ($p < 0.05$) with a PR of 8.894 (95% CI: 1.811–43.675), indicating that alcohol consumption substantially increases the risk of hypertension.

For fruit and vegetable consumption, respondents with low intake had a much higher prevalence of uncontrolled blood pressure (52.6%) compared to those with adequate intake (6.5%). This association was significant ($p < 0.05$) with a PR of 15.957 (95% CI: 7.815–32.581), highlighting the importance of a healthy diet in blood pressure management.

Genetic factors also played a role. Respondents with a family history of hypertension had a prevalence of uncontrolled blood pressure of 80.9%, much higher than those without such history (10.3%). The analysis revealed a significant association ($p < 0.05$) with a PR of 35.471 (95% CI: 17.471–70.291), making family history one of the most dominant risk factors.

In contrast, individual medical history showed no strong association. Although uncontrolled blood pressure was more prevalent in respondents with prior comorbidities (32.4%) than without (24%), this difference was not statistically significant ($p \geq 0.05$).

Smoking behavior was significantly associated with blood pressure control. Smokers had a higher prevalence of uncontrolled blood pressure (52.5%) compared to non-smokers (24.3%), with statistical significance ($p < 0.05$) and a PR of 3.448 (95% CI: 1.918–6.201). This indicates smokers have more than a threefold increased risk of uncontrolled hypertension. Physical activity was also a critical factor. Respondents reporting low physical activity had a prevalence of uncontrolled blood pressure of 57.8%, far higher than those with sufficient activity (4.3%). Statistical testing showed a highly significant relationship ($p < 0.05$) with a PR of 30.553 (95% CI: 13.390–69.715), underscoring low physical activity as a major determinant of uncontrolled hypertension.

Table 3. Results of Dominant Risk Factor Tests with Blood Pressure Control in Hypertension Patients at Caringin Health Center, Tangerang Regency

Variable	B	Wald	Df	Nilai P	OR
Initial Model					
Age	2,947	8,599	1	0,003	19,040
Excessive salt consumption	5, 698	17,758	1	< 0,001	29,800
Alcohol consumption	2,034	0,511	1	0,475	7,644
Fruit and vegetable consumption	8,257	15,906	1	< 0,001	28,540
Family history of hypertension	4,883	17,913	1	< 0,001	13,200
Smoking	0,649	0,448	1	0,504	1,914
Physical activity	2,940	9,661	1	0,002	18,916
Excessive sugar consumption	0,087	0,008	1	0,930	1,090
Excessive fat consumption	5,387	12,868	1	< 0,001	21,800
Personal health history	2,345	3,723	1	0,050	10,435
Final Model					
Age	2,944	8,579	1	0,003	18,984
Excessive salt consumption	5,673	18,581	1	<0,001	29,00

Fruit and vegetable consumption	8,186	18,715	1	<0,001	25,920
Family history of hypertension	4,847	20,639	1	<0,001	12,70
Low physical activity	2,937	9,660	1	0,002	1,899
Excessive fat consumption	5,362	13,313	1	<0,001	21,30
Comorbid disease history	2,352	3,760	1	0,050	10,507
constant	-52,986	19,930	1	19,930	<0,001

The results in Table 3 show that three variables were not significantly associated with blood pressure ($p > 0.05$), namely alcohol consumption, smoking, and excessive sugar consumption. Among these, excessive sugar consumption had the highest p-value ($p = 0.930$), and thus was the first variable removed from the model.

Further analysis revealed that several variables had a significant relationship with an increased risk of hypertension, including age (OR = 18.984; $p = 0.003$), excessive salt consumption (OR = 29.000; $p < 0.001$), insufficient fruit and vegetable intake (OR = 25.920; $p < 0.001$), family history of hypertension (OR = 12.700; $p < 0.001$), low physical activity (OR = 1.899; $p = 0.002$), excessive fat consumption (OR = 21.300; $p < 0.001$), and personal disease history (OR = 10.507; $p = 0.050$). These findings indicate that these factors significantly contribute to an increased risk of hypertension after controlling for other variables in the model.

Specifically, individuals aged 40–64 years have 18.984 times higher risk of hypertension compared to those under 40 years. Excessive salt intake increases the risk by 29 times, while inadequate consumption of fruits and vegetables raises the risk by 25.920 times. A family history of hypertension increases the risk by 12.7 times, and low physical activity nearly doubles the risk (OR = 1.899). Additionally, excessive fat consumption is associated with a 21.3-fold increase in risk, and personal disease history increases the risk by 10.507 times.

On the other hand, alcohol consumption (OR = 7.759; $p = 0.475$) and smoking habits (OR = 1.899; $p = 0.507$) did not show a statistically significant association with hypertension in the final model. This suggests that the influence of these two factors is inconsistent after adjusting for other variables.

The model's intercept value is -52.986 and statistically significant ($p < 0.001$). In logistic regression, the intercept represents the log odds of the event occurring in an individual with no risk factors. Therefore, for individuals under 40 years old who do not consume excessive salt or fat, maintain adequate fruit and vegetable intake, and are physically active, the baseline probability of hypertension is very low (close to zero). These findings confirm that the presence of the investigated risk factors substantially contributes to the increased likelihood of developing hypertension.

This study shows that respondents aged 40–64 years are more likely to have uncontrolled blood pressure compared to those under 40 years. Physiologically, aging affects the cardiovascular system through mechanisms such as reduced arterial elasticity, increased vascular stiffness, and neurohormonal regulation changes that contribute to elevated blood pressure [9] [10] reported that middle-aged individuals in China have nearly twice the risk of uncontrolled hypertension compared to younger groups.

In Indonesia, the 2023 Indonesia Health Profile (SKI) shows a sharp increase in hypertension prevalence starting at age 35, with blood pressure control rates remaining low [9], in South Korea also confirmed that blood pressure control declines significantly from middle to older age, even among patients regularly taking antihypertensive medication. Therefore, aging is linked not only to biological factors but also to behavioral changes, lifestyle, and medication adherence. This highlights the need for promotive and preventive interventions targeting the productive age group to prevent further complications.

Gender also influences blood pressure control. In this study, uncontrolled blood pressure was more prevalent among men than women. Hormonal factors play an important role: women of reproductive age tend to be more protected due to the vasodilatory effects of estrogen, whereas men are more susceptible to hypertension from a young age [11].

A study showed that men have lower medication adherence than women, resulting in poorer blood pressure control. Indonesian data support this finding, showing men are more likely to neglect healthy diets, smoke, and experience higher work-related stress [3] [12]. Conversely, after menopause, women have an increased risk of hypertension due to decreased estrogen levels [13]. These findings underscore the need for hypertension control strategies that consider gender differences, with more tailored education and lifestyle interventions.

Education level is an important social factor affecting hypertension control. Respondents with lower education in this study were more likely to have uncontrolled blood pressure. That lower education correlates with limited hypertension knowledge, poor medication adherence, and reduced access to healthcare [14].

Research also showed that low education is linked to limited understanding of the importance of regular check-ups, healthy diet, and physical activity, leading to poor blood pressure control. National surveys in Indonesia similarly show patients with middle and high education levels more frequently monitor their blood pressure regularly compared to those with low education. Therefore, health education strategies should use simple, communicative, and contextual approaches to improve effectiveness among low-education groups [15].

Obesity, especially central obesity, is strongly associated with poor blood pressure control. Respondents with obesity in this study tended to have uncontrolled hypertension. The main mechanisms involve increased insulin resistance, hyperactivation of the renin-angiotensin-aldosterone system, and heightened sympathetic activity [16].

A multicenter study found that hypertensive patients with obesity are more likely to have resistance to antihypertensive drugs. Indonesian studies support this, identifying obesity as a primary determinant of hypertension in the productive age group. Thus, hypertension management must include weight reduction interventions through diet and physical activity [17].

Physical inactivity is associated with uncontrolled blood pressure. Respondents who rarely exercised experienced uncontrolled hypertension more often than those who were regularly active. Physical activity improves insulin sensitivity, endothelial function, promotes weight loss, and reduces sympathetic nervous system activity [15].

A meta-analysis reported that regular aerobic exercise lowers systolic blood pressure by an average of 5–8 mmHg. In Indonesia, a study found that hypertensive patients who exercised at least 150 minutes per week had better blood pressure control than inactive patients. Therefore, physical activity should be a key component of community-level hypertension management programs [9] [18]

Dietary patterns, especially high intake of salt, saturated fats, and low fiber, are linked to poor blood pressure control. This study found that respondents with unhealthy diets had higher rates of uncontrolled blood pressure.

The study also showed a dose-response relationship: the higher the fruit and vegetable intake, the lower the blood pressure and hypertension risk. Mechanisms include potassium-induced natriuresis, natural nitrates causing vasodilation, polyphenols supporting endothelial function, fiber reducing energy density, and displacement of high sodium/fat foods. The DASH diet (Dietary Approaches to Stop Hypertension) demonstrates that a diet rich in fruits, vegetables, and low in sodium can significantly reduce blood pressure [18]. Recent research also confirms that excessive salt intake strongly predicts uncontrolled hypertension. In Indonesia, average sodium consumption remains above the WHO recommendation of 3.7 grams/day (SKI, 2023). This indicates a need for intensive nutrition education to change public consumption behavior [19].

These findings showing strong effects are valid, but odds ratios around 25 may overestimate the impact of common dietary exposures; measuring portion sizes per day and using hierarchical modeling can improve accuracy.

Physiologically, nicotine acutely raises blood pressure via sympathetic activation and vasoconstriction. However, long-term causal evidence linking nicotine to "chronic" hypertension is mixed: some cohorts and Mendelian randomization studies show increased risk, while others weaken after controlling for body weight (smokers tend to have lower BMI) and other lifestyle factors. Smoking cessation interventions in hypertensive patients improve blood pressure control. Since smoking was not significant in your final model, this aligns with global heterogeneous evidence—though smoking remains an important cardiovascular intervention target.

Comorbidities such as diabetes mellitus and chronic kidney disease also contribute to poor blood pressure control. Respondents with comorbidities in this study had more uncontrolled hypertension. This agrees who showed hypertensive patients with diabetes or kidney disease have more challenging blood pressure targets [20]. In Indonesia, the study found hypertensive patients with diabetes have lower medication adherence and higher complication rates.

Conclusion

Managing hypertension in patients with comorbidities requires a comprehensive, multidisciplinary approach and close monitoring.

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