



Detection of Psychobiological, Environmental, and Behavioral Risk Factors on Hypertension Prevention Efforts in Agro-Industrial Communities

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ABSTRACT

Background : Hypertension is one of the leading non-communicable diseases that contributes significantly to global mortality and imposes a major economic and public health burden, including in Indonesia. The agro-industrial community has a high level of vulnerability to hypertension due to the complex interplay of psychobiological, environmental, and behavioral risk factors. Effective hypertension prevention strategies need to consider these factors to ensure that interventions are well-targeted and sustainable.

Objective : To determine the influence of psychobiological, environmental, and behavioral risk factors on hypertension prevention efforts among the agro-industrial community in Trenggalek Regency.

Methods: This study employed an analytical observational design with a cross-sectional approach. A total of 348 respondents,

representing the agro-industrial community, were selected using a systematic random sampling technique. Data were collected using a structured questionnaire that had been tested for validity and reliability. Data analysis was performed using the Structural Equation Modeling–Partial Least Squares (SEM–PLS) method.

Results: : The results showed that the three main factors—psychobiological (age, sex, and genetics), environmental (stress and social well-being), and behavioral (dietary habits, smoking, and physical activity)—significantly influenced hypertension prevention efforts. Primary and secondary prevention had a greater impact on reducing hypertension risk compared to tertiary prevention. Age, educational level, and smoking habits were the most dominant factors affecting hypertension prevention.

Conclusion: The study concludes that psychobiological, environmental, and behavioral factors significantly affect hypertension prevention efforts among the agro-industrial community.

Keywords: Psychobiological Factors, Environmental Factors, Behavioral Factors, Hypertension Prevention Efforts, Agro-industrial Community

INTRODUCTION

Hypertension is classified as a Non Communicable Disease (NCD), yet it remains a dominant contributor to the global healthcare burden. Although it is not transmitted through direct contact between individuals, the number of cases continues to increase along with improvements in living standards and lifestyle changes. Factors such as physical activity patterns, dietary habits, stress levels, and degenerative processes associated with aging and longer life expectancy contribute to the rising prevalence of hypertension. Previously, hypertension was commonly regarded as a degenerative disease among the elderly; however, it is now increasingly prevalent among younger populations due to lifestyle shifts across various social groups, particularly among the younger generation. This condition indicates that knowledge, attitudes, and behaviors play an essential role in addressing hypertension (Vansa and Anshari, 2020).

Hypertension is known as the “silent killer” because it often presents no specific clinical signs and frequently goes unnoticed by patients. Its prevalence continues to rise, particularly in developing countries, where most people work in natural resource-based sectors such as agroindustrial communities (Fatchanuralityah, Subronto, and Febrianora, 2023; Lukito, 2023). The agroindustrial community has a high level of vulnerability to hypertension due to the combined influence of psychobiological, environmental, and behavioral risk factors. Psychobiological factors, such as genetics, age, and sex, contribute to an individual’s likelihood of developing hypertension. Environmental factors including unhealthy dietary patterns, limited physical activity, air pollution exposure, and occupational conditions that do not support health further elevate the risk. In addition, behavioral factors such as smoking, excessive salt and alcohol consumption, stress, and lack of knowledge about blood pressure management play a critical role (Astuti et al., 2024).

According to the World Health Organization (2011), approximately one billion people worldwide suffer from hypertension, with two thirds living in low to middle income developing

countries. WHO estimates that by 2025, the global prevalence of hypertension will reach 29% among adults. Each year, hypertension is responsible for around eight million deaths, with about 1.5 million occurring in Southeast Asia. Data from the Indonesian Ministry of Health show that the prevalence of hypertension among individuals aged ≥ 18 years is 25.8%. Based on the 2013 Basic Health Research (Riskesdas) survey, provinces with the highest prevalence were Bangka Belitung (30.9%), South Kalimantan (30.8%), East Kalimantan (29.6%), and West Java (29.4%). The Riskesdas data also indicated that the prevalence of hypertension diagnosed by healthcare professionals was 9.4%, increasing slightly to 9.5% when including those under medical treatment. The 2018 Riskesdas reported a further increase to 34.1%, with South Kalimantan showing the highest rate (44.1%). In East Java, the prevalence reached 26.2%, with the highest proportion among individuals aged ≥ 75 years (62.4%).

Data from the Trenggalek District Health Office (2018) indicated that hypertension was the most prevalent non-communicable disease, accounting for 36.6% of all cases. According to the 2022 Trenggalek Health Profile (Dinkes P2KB), the number of hypertensive individuals aged >15 years reached 277,484, or approximately 39.6% of the total population of 700,716. This finding highlights that hypertension is a major public health issue in the region. Trenggalek Regency has distinctive geographical characteristics, consisting of mountainous and coastal areas, which have led most of its population to work in the agroindustrial sector. Based on data from the Central Statistics Agency (BPS), 43.46% of residents are employed in agriculture, 27.32% in manufacturing, and 29.22% in services. The dominance of the agricultural sector underscores the importance of addressing hypertension prevention within agroindustrial communities.

Table 1. Distribution of the Working Population by Sector

Description	2018	2019	2020	2021
Agriculture	48.48	47.15	42.61	43.46
Manufacturing	1.44	1.23	1.40	27.32
Services	13.81	14.70	15.66	29.22
Total	100.00	100.00	100.00	100.00

Research on detecting psychobiological, environmental, and behavioral risk factors related to hypertension prevention among agro-industrial communities is essential to reducing the burden of this disease. A comprehensive understanding of the factors contributing to hypertension development in this population will allow for the design of effective and sustainable prevention strategies (Astuti et al., 2024). This study aims to identify and analyze the psychobiological, environmental, and behavioral risk factors that influence hypertension prevention efforts among the agro-industrial community in Trenggalek Regency. The findings are expected to serve as a basis for formulating more effective prevention strategies at both regional and national levels, particularly among communities with similar characteristics in Indonesia.

METHODS

This study employed an analytical observational method with a cross-sectional design and was conducted at the Public Health Center (UPT Puskesmas) of the Trenggalek District Health Office in February 2025. The study population consisted of the agro-industrial community in the area, while the sample included agroindustrial workers selected from various sectors within the service area of the UPT Puskesmas Trenggalek. The sample size was determined using the Slovin formula, based on a total population of 2,644 individuals and a 5% margin of error, resulting in a sample of 348 respondents.

The sampling technique used was **systematic random sampling**, which involves selecting samples at specific intervals among the available population (Setyawan, 2017). This technique is a simple random sampling method that ensures the selected sample represents the characteristics of the population, thereby maintaining proportionality. Proportionality means that the number of samples within a given subgroup corresponds to its proportion within the population (Magdalena, Nurkholifah, and Hatta, 2015).

Inclusion criteria included agro-industrial community members who were willing to participate as respondents, cooperative, provided clear and accurate information in the questionnaire according to the instructions, resided within the study area, and were registered at the UPT Puskesmas Trenggalek. **Exclusion criteria** included individuals who were not residents of the area, were not part of the agroindustrial community, or were unwilling to complete all research procedures. Data collection was carried out through the distribution of questionnaires accompanied by informed consent forms, where respondents were asked to read, understand, and complete all questions, with assistance from researchers if necessary.

The collected data were analyzed using the **Structural Equation Modeling Partial Least Squares (SEM-PLS)** method, employing a multivariate analytical approach. The analysis consisted of two stages: the **outer model**, used to assess the validity and reliability of indicators (considered valid if the outer loading value > 0.5), and the **inner model**, used to test relationships between variables. The structural model was deemed significant when the p-value was less than 0.05.

RESULTS

Data collection for this study on the detection of psychobiological, environmental, and behavioral risk factors influencing hypertension prevention efforts among the agro-industrial community was completed at the UPT Puskesmas of the Trenggalek District Health Office, involving a total of 348 respondents. Based on respondent characteristics, the majority were aged **15–34 years** (238 individuals, 68.39%), followed by those aged **35–54 years** (74 individuals, 21.26%), **over 55 years** (33 individuals, 9.48%), and **under 15 years** (3 individuals, 0.86%). By gender, the majority were **female** (232 individuals, 66.7%), while **male** respondents accounted for 116 individuals (33.3%). In terms of educational attainment, most respondents were **university graduates (bachelor/diploma)** (202 individuals, 58.0%), followed by **senior high school/vocational school graduates** (139 individuals, 39.9%), and **elementary school graduates** (7 individuals, 2.0%).

Table 2. Respondent Characteristics

Characteristic	Category	Frequency	Percentage (%)
Age	<15 years	3	0,86
	15-34 years	238	68,39
	35-54 years	74	21,26
	>55 years	33	9,48
Gender	Male	116	33,3
	Female	232	66,7
Education Level	Not in School	-	-
	Elementary School	7	2,0
	Senior High/Vocational School	139	39,9
	Bachelor/Diploma	202	58,0

Evaluation of the SEM–PLS model fit was conducted through analysis of both the **outer model** and the **inner model**. The outer model was assessed based on the **outer loading** values, as the indicator model used was reflective–informative, deemed most appropriate to describe the relationships among constructs in this study. The analysis was conducted using a **second order model**, with the **first order model** representing the relationship between indicators and subvariables, and the **second order model** representing the relationship between subvariables and variables.

Psychobiological factors in the first order model, all indicators sex (X1.1), genetic (X1.2.a), and age (X1.3) showed outer loading values of 1.000, indicating they were all significant in explaining the subvariables (Table 2). In the second order model, the sub-variable sex had a path coefficient of 0.434 with a p value of 0.00, genetic had 0.456 with a p value of 0.00, and age had 0.749 with a p-value of 0.00. All were significant, with age (X1.3) being the strongest indicator of the psychobiological factor.

Table 3. First Order Reflective Model Evaluation for Psychobiological Factors

Subvariable	Indicator	Outer loading	Result
Sex	X1.1	1,000	Significant
Genetic	X1.2.a	1,000	Significant
Age	X1.3	1,000	Significant

Table 4. Second Order Reflective Model Evaluation for Psychobiological Factors

Subvariable	Path Coefficient	P Value	Result
Sex	0,434	0,00	Significant
Genetic	0,456	0,00	Significant
Age	0,749	0,00	Significant

Environmental factors in the first order model, the stress indicator (X2.1.a) had an outer loading value of 1.000, social well-being 1 (X2.2.a) had 0.858, and social well-being 2 (X2.2.b) had 0.616. All values exceeded 0.5, indicating significance in explaining the sub-variables. In the second order model, the stress subvariable had a path coefficient of 0.422 ($p = 0.00$), and social well being had 0.718 ($p = 0.00$). Thus, both were significant, with social well-being (X2.2) being the strongest indicator of the environmental factor.

Table 5. First Order Reflective Model Evaluation for Environmental Factors

Subvariable	Indicator	Outer loading	Result
Stress	X2.1.a	1,000	Significant
Social Well being	X2.2.a	0,858	Significant
	X2.2.b	0,616	Significant

Table 6. Second Order Reflective Model Evaluation for Environmental Factors

Subvariable	Path Coefficient	P Value	Result
Stress	0,422	0,00	Significant
Social Well-being	0,718	0,00	Significant

Behavioral factors in the first order model, indicators of dietary pattern (X3.1.a) and (X3.1.b) had outer loading values of 0.830 and 0.835, respectively. Indicators of smoking (X3.2.a) and (X3.2.b) had 0.648 and 0.809, while indicators of physical activity (X3.3.a) and (X3.3.b) had 0.863 and 0.874. All indicators had outer loading values >0.5 , indicating significance. In the second order model, the dietary pattern subvariable had a path coefficient of 0.505 ($p = 0.00$), smoking 0.656 ($p = 0.00$), and physical activity 0.364 ($p = 0.00$). All were significant, with smoking (X3.2) being the strongest indicator of the behavioral factor.

Table 7. First Order Reflective Model Evaluation for Behavioral Factors

Subvariable	Indicator	Outer loading	Result
Dietary Pattern	X3.1.a	0,830	Significant
	X3.1.b	0,835	Significant
Smoking	X3.2.a	0,648	Significant
	X3.2.b	0,809	Significant
Physical Activity	X3.3.a	0,863	Significant
	X3.3.b	0,874	Significant

Table 8. Second Order Reflective Model Evaluation for Behavioral Factors

Subvariable	Path Coefisient	P Value	Result
Dietary Pattern	0,505	0,00	Significant
Smoking	0,656	0,00	Significant
Physical Activity	0,364	0,00	Significant

Hypertension prevention efforts in the first order model, indicators of primary prevention (Y.1.a) and (Y.1.b) had outer loading values of 0.787 and 0.892, respectively; secondary prevention (Y.2.a) and (Y.2.b) had 0.949 and 0.949; and tertiary prevention (Y.3.a) had 1.000. All indicators showed outer loading values >0.5, indicating significance. In the secondorder model, primary and secondary prevention sub-variables were significant ($p = 0.00$), while tertiary prevention was not ($p = 1.000$). Thus, primary (Y.1) and secondary (Y.2) prevention were the strongest indicators of hypertension prevention efforts.

Table 9. First Order Reflective Model Evaluation for Hypertension Prevention Efforts

Subvariable	Indicator	Outer loading	Result
Primary Prevention	Y.1.a	0,787	Significant
	Y.1.b	0,892	Significant
Secondary Prevention	Y.2.a	0,949	Significant
	Y.2.b	0,949	Significant
Tertiary Prevention	Y.3.a	1,000	Significant

Table 10. Second Order Reflective Model Evaluation for Hypertension Prevention Efforts

Subvariable	Path Coefisient	P Value
Primary Prevention	0,00	Significant
Secondary Prevention	0,00	Significant
Tertiary Prevention	1,000	Not Significant

Structural model (inner model) evaluation the inner model evaluation was performed through hypothesis testing to determine the relationships between independent and dependent variables. The results showed that all variables had p values < 0.05 , indicating significant relationships between psychobiological, environmental, and behavioral risk factors and hypertension prevention efforts among the agroindustrial community at UPT Puskesmas Trenggalek. Therefore, the study confirmed significant associations between the three independent variables and hypertension prevention efforts.

Table 11. Structural Model (Inner Model) Path Coefficients

Variable Relationship	<i>P</i> <i>value</i>	Description
Psychobiological risk factors (X1) → Hypertension prevention efforts (Y)	0,00	Significant
Environmental risk factors (X2) → Hypertension prevention efforts (Y)	0,00	Significant
Behavioral risk factors (X3) → Hypertension prevention efforts (Y)	0,00	Significant

DISCUSSION

The results of this study showed that the majority of respondents were aged 15–34 years (68.39%). This indicates that most respondents were within the productive age group, actively engaged in social and economic activities, and had easier access to health information. This finding aligns with the data from the Trenggalek Central Statistics Agency (BPS) in 2023, which stated that the productive age population dominates rural areas with agricultural and agroindustrial bases (Tim Penyusun LPPD Kabupaten, 2023). This age group tends to have high work activity levels but often neglects dietary patterns, physical activity, and stress management, making them an important target for hypertension prevention efforts. Regarding gender, the majority of respondents were female (66.7%), indicating active female participation in community health programs such as Posyandu and village-based health initiatives. Women are generally more responsive to family health issues and therefore play a strategic role in family and community based hypertension prevention. In terms of education level, most respondents held a bachelor's or diploma degree (58.0%) or a senior high school/vocational school degree (39.9%), reflecting a relatively high level

of health literacy. Higher education levels in Trenggalek are associated with better health conditions, higher socioeconomic status, and healthier lifestyles.

The analysis results indicated that psychobiological, environmental, and behavioral factors influence hypertension prevention efforts. Psychobiological factors included sex, genetics, and age, with age being the most dominant factor. Age is closely related to an increased risk of hypertension due to reduced vascular elasticity and systemic cardiovascular changes, such as arterial stiffening caused by the accumulation of collagen in the arterial wall muscles. This process narrows and stiffens blood vessels, leading to elevated blood pressure and, consequently, hypertension. The risk of hypertension increases significantly after the age of 55 (Soenarta et al., 2015). Although most respondents were aged 15–34 years, younger individuals still face a risk of hypertension, particularly when coupled with unhealthy lifestyles. Individuals aged 20–45 years who are overweight and sleep less than six hours per day have a significantly higher risk of developing hypertension. In addition, psychobiological stress, high salt intake, physical inactivity, and behaviors such as smoking also contribute to early-onset hypertension (Meher, Pradhan, and Pradhan, 2023). Therefore, hypertension prevention should begin early through lifestyle education, regular physical activity, reduced salt intake, and stress management.

Genetic and sex factors also influence hypertension prevention. Research by Kolifarhood et al. showed that genetic predisposition within families plays an important role in hypertension development. Specific gene variations, such as AGT and NLGN1, have been associated with increased blood pressure. Furthermore, gene - gene interactions also contribute to hypertension risk. This finding implies that individuals with a family history of hypertension have a higher likelihood of developing the disease (Kolifarhood et al., 2021). A study by Ji et al. found that women exhibit different blood pressure trajectories compared to men. Women experience earlier increases in blood pressure, beginning around age 30, and the rate of increase progresses more rapidly than in men (Ji et al., 2020). Non pharmacological interventions such as mindfulness (Loucks, Schuman-Olivier et al., 2023), DASH and Mediterranean diets (Chen, Liu, and Du, 2024; Loucks, Kronish et al., 2023),

and regular physical activities such as Tai Chi (Li et al., 2024) have been proven effective in lowering blood pressure. Thus, young adulthood should be viewed as a critical period for initiating hypertension prevention to avoid long term cardiovascular complications in later life.

Environmental factors include stress and social well-being, with social well being particularly educational attainment being the dominant aspect. Higher education enhances health literacy, awareness of healthy lifestyles, and compliance with preventive measures. Conversely, low education levels are often associated with lower socioeconomic status, which limits access to nutritious food, healthy living conditions, and healthcare services. Low educational attainment correlates with an increased risk of cardiovascular diseases such as hypertension through the accumulation of risk factors like stress, unhealthy lifestyles, and limited healthcare access (Abdalla et al., 2025). Education also has a long-term protective effect on cardiovascular health. Higher education levels are associated with a 24–33% reduction in hypertension risk and a 10–15% reduction in uncontrolled hypertension compared to individuals with lower education levels (Sun et al., 2022). The protective role of education in hypertension prevention through improved health literacy and healthcare access is consistent with the prevention efforts observed in agroindustrial communities (Pacca et al., 2025). Prevention strategies can be strengthened through community-based education, health counseling, and the development of local cultural health cadres.

Behavioral factors such as dietary habits, smoking, and physical activity also influenced hypertension prevention, with smoking identified as the most dominant factor. Smoking causes endothelial dysfunction and increases blood pressure. Among agroindustrial workers, smoking rates tend to be higher due to flexible fieldwork environments, physical and psychological work stress, and limited access to health information and education. Cigarette smoke contains harmful substances such as nicotine and free radicals, which induce oxidative stress and inflammation, damaging blood vessel walls (Higashi, 2023). This process disrupts nitric oxide (NO) release a natural vasodilator resulting in vascular stiffness and elevated blood pressure (Rahman et al., 2025).

Exposure to cigarette smoke also leads to endothelial dysfunction, oxidative stress, and vascular inflammation (Klein et al., 2023).

Research by Gaya et al. reported that after three months of smoking cessation, systolic blood pressure decreased by 6 mmHg and diastolic pressure by 3–4 mmHg, indicating immediate cardiovascular benefits (Gaya et al., 2024). Therefore, smoking cessation programs, health education, and smoke-free workplace policies are crucial for hypertension prevention. Family support, regular exercise, and healthy dietary habits further contribute to maintaining blood pressure. Behavioral changes should be implemented comprehensively and sustainably.

Hypertension prevention encompasses primary, secondary, and tertiary levels. Primary prevention has the greatest influence on reducing hypertension risk. The DASH diet lowers systolic blood pressure by 6.74 mmHg and diastolic pressure by 3.54 mmHg (Utami, 2021). Regular physical activity reduces systolic blood pressure by 5–8 mmHg (Pescatello et al., 2019). A combination of a healthy diet and physical exercise can reduce systolic pressure by 9.9 mmHg and diastolic pressure by 6.3 mmHg (Krishnamoorthy et al., 2023). Secondary prevention is crucial for reducing the risk of hypertension complications. Community screening programs can reduce cardiovascular complications by up to 25% (Putu Sudayasa et al., 2023). The use of self-monitoring blood pressure devices improves blood pressure control (Tucker et al., 2017). Community based non communicable disease programs such as Posbindu PTM have been effective in raising public awareness about hypertension risk (Ariyani and Setiawan, 2024; Rochmah et al., 2023). Tertiary prevention focuses on preventing organ damage and maintaining quality of life in hypertensive patients (Carey et al., 2019), although its influence is smaller in this study due to the predominance of healthy, productive-age respondents.

Overall, psychobiological (age, genetics, sex), environmental (stress, education), and behavioral (diet, smoking, physical activity) factors significantly influence hypertension prevention among agro-industrial communities. Primary and secondary prevention are the most dominant,

emphasizing healthy lifestyles, community education, and early detection. Productive age, higher education, dietary habits, and smoking behavior are key aspects in achieving sustainable hypertension prevention

CONCLUSION

This study provides several important conclusions. Psychobiological, environmental, and behavioral factors were proven to influence hypertension prevention efforts among the agroindustrial community. Psychobiological factors affected hypertension prevention, with age identified as the dominant aspect that plays a key role in encouraging individuals to engage in early preventive measures. Environmental factors also contributed to hypertension prevention, particularly social well being based on educational attainment, which influences health literacy and individual participation in preventive efforts. In addition, behavioral factors also affected hypertension prevention, with smoking identified as the dominant aspect that significantly influences lifestyle changes. Increasing physical activity is also necessary to ensure that prevention strategies are more effective, relevant, and sustainable in reducing hypertension risk.

Based on these findings, several recommendations can be proposed. For the agro-industrial community, it is recommended to enhance knowledge and understanding of hypertension prevention and its influencing factors through educational programs and reliable health information sources. The community is encouraged to adopt a healthy diet by limiting the intake of foods high in salt, fat, and sugar, and by increasing the consumption of fruits and vegetables as recommended. In addition, individuals should avoid smoking and alcohol consumption, as both can elevate blood pressure. Stress management should be practiced effectively through social support, relaxation techniques, and balanced work-rest schedules, along with regular physical activity suited to individual capabilities. Routine blood pressure monitoring, either self-measured or through healthcare facilities, is also strongly recommended.

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