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(REVIEW ARTICLE)

Meta-analysis study: Risk analysis of eating habits, smoking habits, physical activity, and stress on the incidence of hypertension in Indonesia

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Abstract

Hypertension which is included in the class of non-communicable diseases, is a condition where systolic and diastolic blood pressure exceeds the limit. The blood pressure limit is 140/90 mmHg (systolic/diastolic). This meta-analysis study aims to analyze the relationship between risk factors for hypertension in Indonesia, which is limited to eating habits, smoking habits, physical activity, and stress. This study used the meta-analysis method by collecting 52 previous research articles. Data were processed using Microsoft Excel and analyzed using JASP (Jeffrey's Amazing Statistics Program) software. The results of the meta-analysis study showed that the risk factors of eating habits had a value of 9,583 times greater, smoking habits 2,857 times greater, physical activity 3,896 times greater, and stress 4,349 times greater to develop hypertension. Based on these results, it can be concluded that the most influential factor for hypertension is eating habits, while the least influential factor is smoking habits.

Keywords: Hypertension; Eating Habits; Smoking Habits; Physical Activity; Stress

1. Introduction

Hypertension which is included in the class of non-communicable diseases, is a condition where systolic and diastolic blood pressure exceeds the limit. The blood pressure limit is 140/90 mmHg [1]. Hypertension that is not treated quickly can develop into a serious problem, causing dangerous complications such as heart-related diseases, kidney problems, stroke, and visual impairment. In certain cases, hypertension can cause death [2]. Hypertension affects about 22% of the total population in the world. The highest incidence rate of hypertension is in the African continent at 27%, while the lowest is recorded in the Americas at 18%. In Southeast Asia alone, the incidence rate of hypertension is in the third highest position at 25% [3]. The results of the Indonesian Basic Health Research show that in 2017 the incidence rate of hypertension in Indonesia was around 31.7% and continued to increase to 34.1% in 2018. Hypertension in Indonesia that occurs in the elderly aged 60-64 years is 45.9%, age 65-74 years is 57.6%, and age over 75 years is 63.8% [4].

In the early stages of hypertension, it is often associated with stroke or heart attack which can occur suddenly. Although there are no specific symptoms that identify hypertension, most people suffering from hypertension often experience headaches, fatigue, and an irregular heartbeat [5]. Risk factors for hypertension can be grouped into controllable and uncontrollable factors. The controllable risk factors include diet, physical activity, and smoking. Uncontrollable risk factors include age, gender, and family history [6]. This study aims to analyze the relationship between risk factors, including eating habits, smoking habits, physical activity, and stress, with the incidence of hypertension in Indonesia by meta-analyzing data from various research articles. By using meta-analysis methods, researchers can combine the findings of multiple small studies to provide a more comprehensive picture, revealing the extent of their influence and accuracy.

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2. Material and methods

This study applied a meta-analysis method with statistical techniques to integrate quantitative data from various previous studies on similar topics. The data was then analyzed using software to draw conclusions. The focus of this study included hypertension, diet, smoking, physical activity, and stress. While the methods used are objective and the results can be measured quantitatively, it is still important to apply proper inclusion and exclusion criteria.

In this study, the authors selected 52 articles from previous studies accessed through Google Scholar using keywords such as hypertension, diet, smoking, physical activity and stress. The articles had full structure and text and met the criteria set for this meta-analysis. The steps of selecting eligible articles are illustrated in the following diagram.

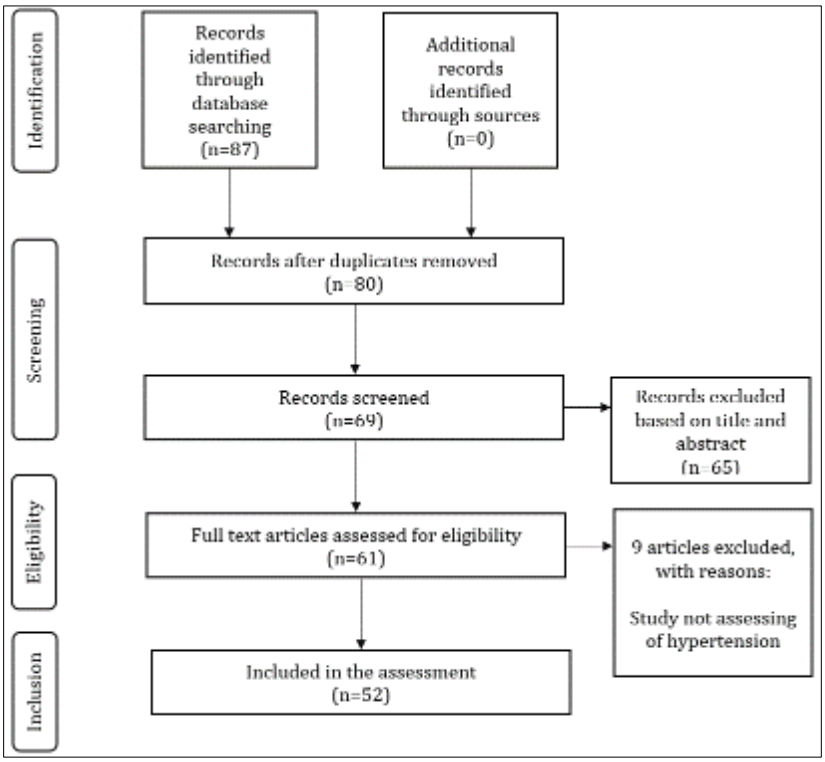

Figure 1 Flow Diagram of The Meta-Analysis Research

The next step in this study was to enter the treat positive, treat negative, outcome positive, and outcome negative data from the articles into Microsoft Excel to calculate the Odds Ratio (OR), Log OR, and Standard Error Log OR values. After the inputting and calculation process was complete, the analysis continued using JASP (Jeffrey's Amazing Statistics Program) to test for sensitivity and bias in the study. Two methods were used to obtain combined odds ratio estimates: Mentel-Haenszel fixed effects model and the Der Simonian-Laird random effects model. For variables with significant heterogeneity (heterogeneity p-value less than 0.05), the fixed effects model was used. In this meta-analysis, the Prevalence Ratio (PR) value was calculated as follows:

- If the PR value > 1 and the confidence interval range ≤ 1, then the independent variable has a significant relationship with the dependent variable.
- If the PR value < 1 and the confidence interval range > 1, then the independent variable is a protective factor of the dependent variable.
- If the PR value = 1 and the confidence interval range ≤ 1, then the independent variable has no significant relationship with the dependent variable.

3. Results and discussion

Risk analysis of eating habits, smoking habits, physical activity, and stress with the incidence of hypertension in Indonesia.

3.1. Risk Analysis of Eating Habits on the Incidence of Hypertension

The heterogeneity test of the risk factors of eating habits obtained a *p*-value < α, which is < 0.001, as shown in Table 1. This finding indicates that there is variation between studies (heterogeneous). Therefore, the analysis was carried out using the Restricted ML Model.

Table 1 Heterogeneity Test Meta-Analysis of Eating Habits and Hypertension with Restricted ML Model

	Q	df	*p*
Omnibus test of Model Coefficients	49.334	1	< .001
Test of Residual Heterogeneity	50.855	12	< .001

Note. p-values are approximate; The model was estimated using Restricted ML Model

Figure 2 shows the the estimated PR based on the Restricted ML model. Based on the forest plot image of 13 research articles, the 95% CI prevalence ratio value is 2.26, with an impact range of 1.63-2.89. In addition, the forest plot results showed a combined prevalence ratio = $e^{2.26}$ = 9.583. These results indicate that poor eating habits have a 9.583 times greater risk of causing hypertension than good eating habits. Figure 3 shows the funnel plot of the risk factors of eating habits with hypertension. The figure shows that there is an indication of publication bias because several plots are still scattered outside the triangle area. Furthermore, based on the Egger test in Table 2 the *p*-value < α, which is 0.003, indicating that there is evidence of significant publication bias in the research articles used.

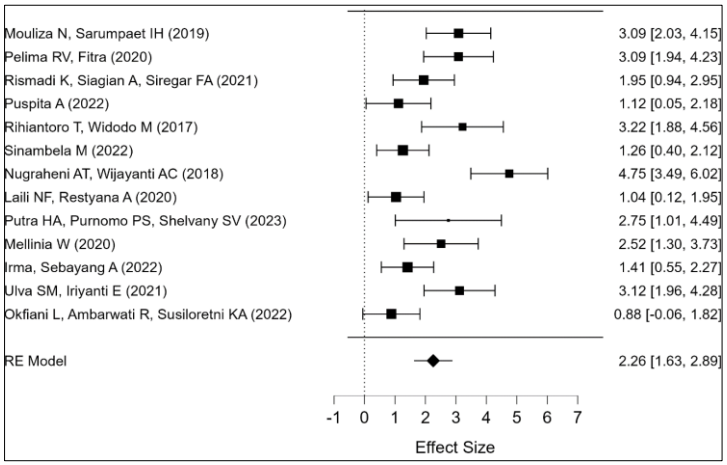

Figure 2 Forest Plot of Eating Habits with Hypertension Incidence

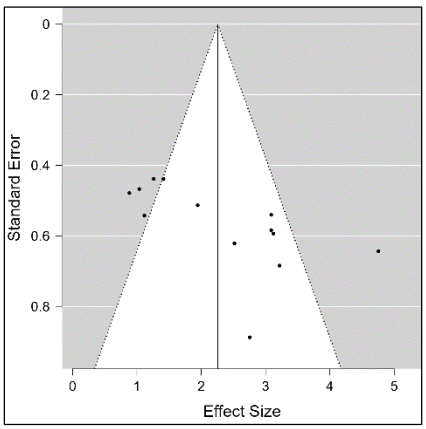

Figure 3 Funnel Plot of Eating Habits with Hypertension Incidence

Table 2 Egger's Test Meta Analysis of Eating Habits with Hypertension

	z	*p*
Egger's Test	2.985	0.003

Eating habits are one of the risk factors that can increase the incidence of hypertension. This is in line with research conducted on young adult women in Sukoharjo Regency in 2017, which states that there is a significant relationship between eating habits and the incidence of hypertension (*p*-value = 0.000 and OR = 116, 95% CI 32.854-409.567) [6]. Another study was also conducted in Tulang Bawang Regency in 2017, which states that there is a significant relationship between eating habits and the incidence of hypertension (*p*-value = 0.000 and OR = 25, 95% CI 2.187-8.494) [6]. In addition, there was also research conducted in Ambesia Village, Parigi Moutong Regency in 2020, which stated that there was a significant relationship between eating habits and the incidence of hypertension (*p*-value = 0.004 and OR = 5.971, 95% CI 1.901-18.754) [2].

According to Palmer and Williams in 2007, an unhealthy diet is a major risk factor for hypertension. They pointed out that excessive consumption of salt and sugar, as well as foods high in saturated fat, along with a lack of fruit and vegetable intake, can lead to high blood pressure and other cardiovascular diseases [7]. In addition to the type of food consumed, the frequency of meals can also be a risk factor for hypertension. Overeating can lead to obesity, which in turn increases the risk of infection [8].

3.2. Risk Analysis of Smoking Habits on the Incidence of Hypertension

The heterogeneity test of the risk factor of smoking habits obtained a *p*-value < α, which is < 0.001, as shown in Table 3. This finding indicates that there is variation between studies (heterogeneous). Therefore, the analysis was carried out using the ML Restricted Model.

Table 3 Heterogeneity Test Meta-Analysis of Smoking Habits and Hypertension with Restricted ML Model

	Q	df	*p*
Omnibus test of Model Coefficients	33.222	1	< .001
Test of Residual Heterogeneity	50.558	19	< .001

Note. p-values are approximate; The model was estimated using Restricted ML Model

Figure 4 shows the estimated PR based on the Restricted ML model. Based on the forest plot image of 20 research articles, the 95% CI prevalence ratio value is 1.05, with an impact range of 0.69-1.41. In addition, the forest plot results show a combined prevalence ratio = $e^{1.05}$ = 2.857. These results indicate that smoking has a 2.857 times greater risk of causing hypertension. Figure 5 shows the funnel plot of the risk factor for smoking habit with hypertension. The figure shows there is an indication of publication bias because there are several plots that are still scattered outside the triangle area. Furthermore, based on the Egger test in Table 4 the *p*-value > α which is 0.485, indicating no evidence of significant publication bias in the research articles used.

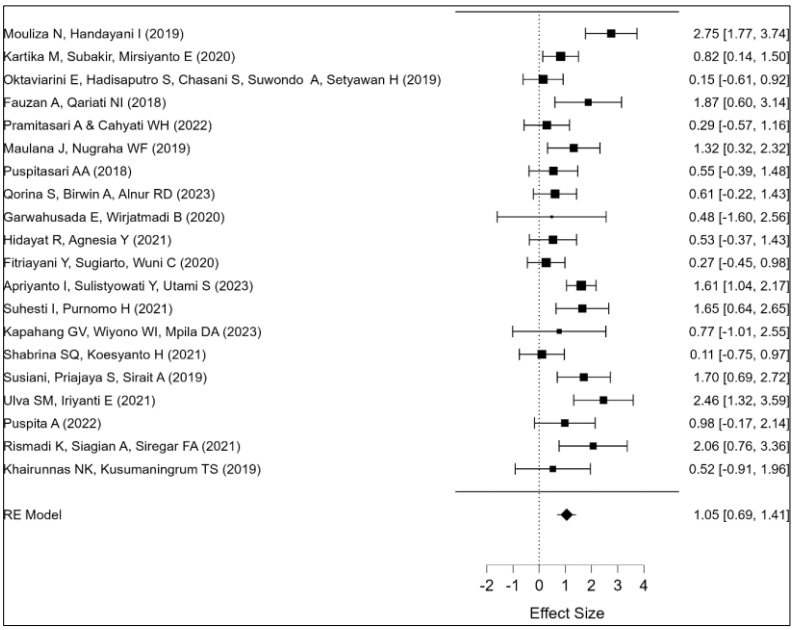

Figure 4 Forest Plot of Smoking Habits with Hypertension Incidence

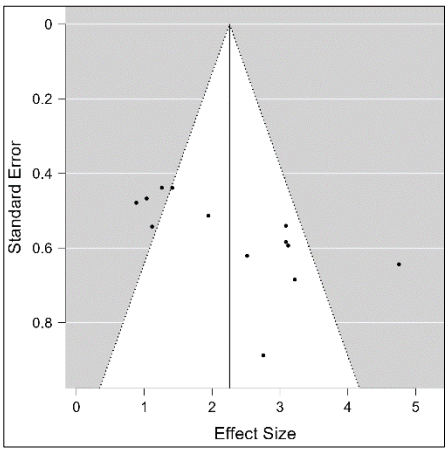

Figure 5 Funnel Plot of Smoking Habits with Hypertension Incidence

Table 4 Egger's Test Meta Analysis of Smoking Habits with Hypertension

	z	***p***
Egger's Test	0.698	0.485

Smoking habit is one of the risk factors that can increase the incidence of hypertension. This is in line with research conducted on employees of the Central Java Provincial Health Office in 2019, which states that there is a significant relationship between smoking habits and the incidence of hypertension (*p*-value = 0.019 and OR = 8.077, 95% CI 1.523-42.834) [9]. Another study was also conducted on the community in the coastal area of Pekalongan City in 2018, which states that there is a significant relationship between smoking habits and the incidence of hypertension (*p*-value = 0.230 and OR = 0.012, 95% CI 0.274-4.258) [10]. In addition, there was also research conducted on the elderly in the Banjarmasin City Health Center work area in 2017, which stated that there was a significant relationship between smoking habits and the incidence of hypertension (*p*-value = 0.006 and OR = 5.971, 95% CI 1.82-23.213) [11]. In contrast, research conducted on machining workers at PT X stated that there was no significant relationship between smoking habits and the incidence of hypertension (*p*-value = 0.664) [12].

Smoking can increase a person's risk of developing hypertension. Smoking habits are related to the number of cigarettes smoked every day. According to Imelda, in 2020, smokers who smoke one pack of cigarettes every day are significantly at risk of developing hypertension [13]. Smoking can increase the risk of hypertension due to the nicotine contained in cigarettes. The nicotine can stimulate the sympathetic nervous system, resulting in constriction of blood vessels. In addition, carbon monoxide in cigarettes can replace oxygen in the blood, causing the heart to work harder and increasing blood pressure [12]. Apart from causing hypertension, smoking can also cause complications of other diseases, one of which is lung function disorders [14].

3.3. Risk Analysis of Physical Activity on the Incidence of Hypertension

The heterogeneity test of the physical activity risk factor obtained a *p*-value < α, which is < 0.001, as shown in Table 5. This finding indicates that there is variation between studies (heterogeneous). Therefore the analysis was carried out using restricted ML.

Table 5 Heterogeneity Test Meta-Analysis of Physical Activity and Hypertension with Restricted ML Model

	Q	**df**	***p***
Omnibus test of Model Coefficients	43.429	1	< .001
Test of Residual Heterogeneity	64.787	19	< .001

Note. p-values are approximate; The model was estimated using Restricted ML Model

Figure 6 shows the estimated PR based on the Restricted ML model. Based on the forest plot image of 20 research articles, the 95% CI prevalence ratio value is 1.36 with an impact range of 0.96-1.77. In addition, the forest plot results show a combined prevalence ratio = $e^{1,36}$ = 3.896. These results indicate that less physical activity has a 3.896 times greater risk of experiencing hypertension compared to regular physical activity. Figure 7 shows the funnel plot of the risk factor of physical activity with hypertension. The figure indicates publication bias because several plots are scattered outside the triangle area. Furthermore, based on the Egger test in Table 6, the *p*-value > α, which is 0.057, indicating no evidence of significant publication bias in the research articles used.

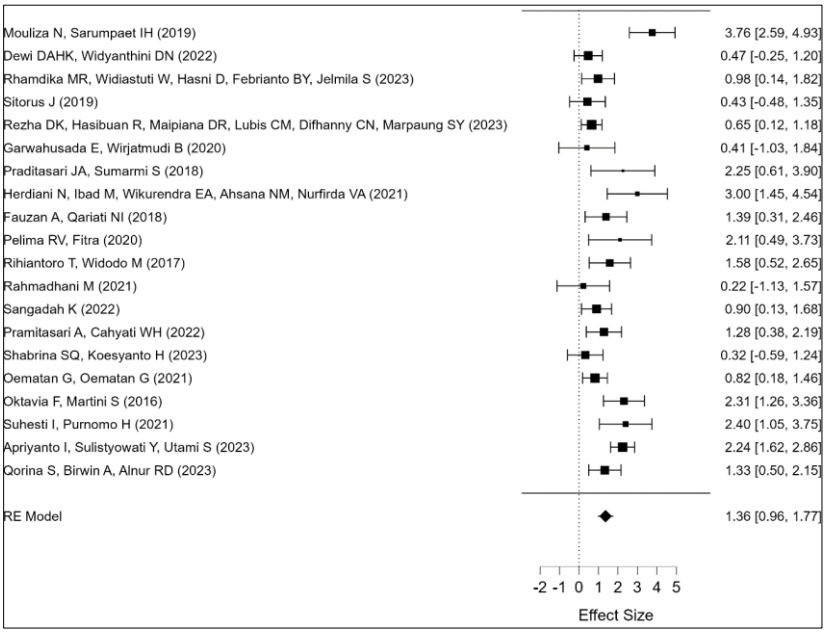

Figure 6 Forest Plot of Physical Activity with Hypertension Incidence

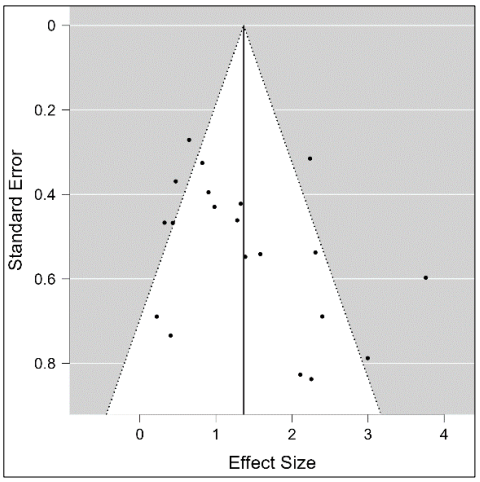

Figure 7 Funnel Plot of Physical Activity with Hypertension Incidence

Table 6 Egger's Test Meta Analysis of Physical Activity with Hypertension

	z	***p***
Egger's Test	1.904	0.057

Physical activity is one of the environmental risk factors that can increase the risk of hypertension. This is in line with research on the community in Belawan I Region in 2023, which states a significant relationship exists between physical activity and the incidence of hypertension (*p*-value = 0.016) [15]. Another study was also conducted on the TNI (Indonesian National Army) in Surabaya in 2016, which states that there is a relationship between physical activity and the incidence of hypertension (OR = 10.06, 95% CI (Confidence Interval) 3.20-34.50) [16]. In contrast, research conducted on employees of the East Java Provincial Health Office in 2020 stated that there was no relationship between physical activity and the incidence of hypertension (*p*-value = 0.122) [7]. This is also supported by research conducted on productive age people in the Ubud I Health Center working area in 2022, which states that physical activity is not associated with the incidence of hypertension (*p*-value = 0.208, OR (Odd Ratio) = 1.578, 95% CI 0.775-3.212) [1].

Physical activity is a modifiable risk factor for hypertension. Physical activity is a movement performed by the body's muscles and support systems [2]. Low physical activity can increase the risk of metabolic syndrome, increase the risk of cardiovascular events, reduce insulin sensitivity and glycemic control, and increase systolic and diastolic blood pressure [17]. The American College of Sports Medicine and the American Heart Association recommend a minimum of 30-60 minutes of moderate-intensity physical activity per week for adults [18].

3.4. Risk Analysis of Stress on the Incidence of Hypertension

The heterogeneity test of stress risk factors obtained a *p*-value < α, which is < 0,001, as shown in Table 7. This finding indicates that there is variation between studies (heterogeneous). Therefore the analysis was carried out using restricted ML.

Table 7 Heterogeneity Test Meta-Analysis of Stress and Hypertension with Restricted ML Model

	Q	**df**	***p***
Omnibus test of Model Coefficients	49,103	1	< ,001
Test of Residual Heterogeneity	39,302	15	< ,001

Note. p-values are approximate; The model was estimated using Restricted ML Model

Figure 8 shows the estimated PR based on the Restricted ML model. Based on the forest plot image of 16 research articles, the 95% CI prevalence ratio value is 1.47, with an impact range of 1.06 – 1.88. In addition, the forest plot results

show a combined prevalence ratio = $e^{1.47}$ = 4.349. These results indicate that high-stress levels have a 4.349 times greater risk of experiencing hypertension compared to low-stress levels. Figure 9 shows the funnel plot of the risk factor of stress with hypertension. The figure shows publication bias because some plots are scattered outside the triangle area. Furthermore, based on the Egger Test in Table 8, the *p*-value is > α, which is 0.685, indicating no evidence of significant publication bias in the research articles used.

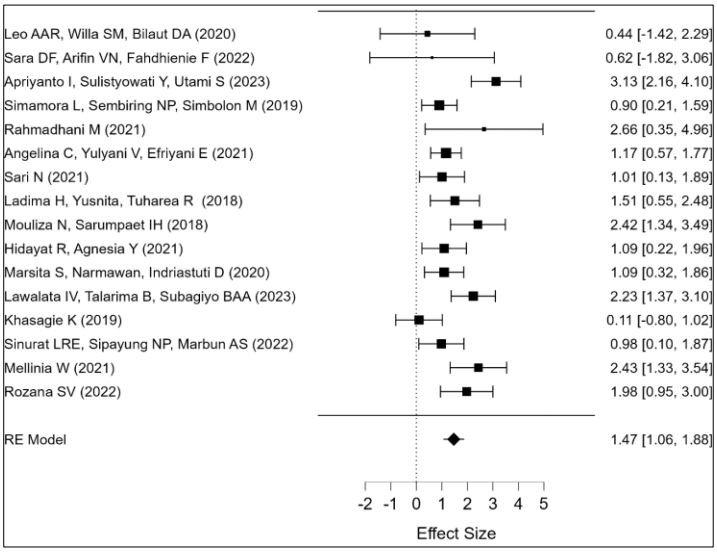

Figure 8 Forest Plot of Stress with Hypertension Incidence

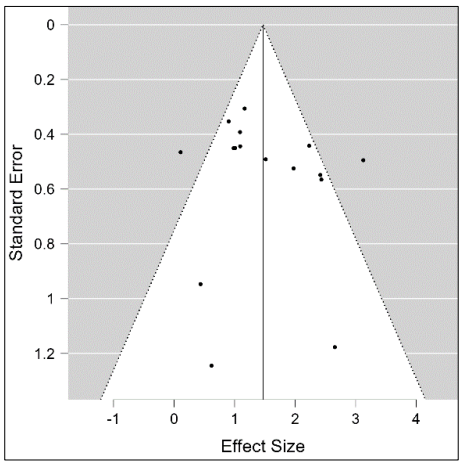

Figure 9 Funnel Plot of Stress with Hypertension Incidence

Table 8 Egger's Test Meta Analysis of Stress with Hypertension

	z	***p***
Egger's Test	0.406	0.685

Stress is one of the environmental risk factors that can increase the risk of hypertension. This is in line with research conducted on the community in the working area of the Biha Pesisir Barat Health Center in 2021, which suggests a significant association between stress and the incidence of hypertension (*p*-value = 0.000, OR = 3.208) [19]. Research in the community in the working area of the North Ternate Siko Care Health Center in 2018 also stated that there was a significant relationship between stress and the incidence of hypertension (OR = 4.583, 95% CI 1.734-11.901) [20]. In contrast, research conducted in Kupang targeting adult men in 2020 stated that there was no significant relationship between stress and hypertension (OR = 1.55, 95% CI 0.24-9.9) [21].

Stress is a physical response that comes with aging and changes in the cardiovascular system. Physiologically, when something is perceived as threatening, the brain's pituitary gland sends a "warning" and hormones to the endocrine glands, which then flow the hormones adrenaline and hydrocortisone into the blood. As a result, the body becomes ready to adjust to the changes [22]. Stress-induced hypertension is related to an increase in the adrenaline hormone in the body, which results in an increase in blood pressure. Stress can increase the heart's work, which will impact increasing blood pressure.

4. Conclusion

The meta-analysis results indicate, the order of risk factors for hypertension starting from the highest is the eating habits variable with a PR value = $e^{2.26}$ = 9.583 (95% CI – 1.63-2.89), stress variable with PR value = $e^{1.47}$ = 4.349 (95% CI – 1.06-1.88), physical activity variable with PR value = $e^{1.36}$ = 3.896 (95% CI– 0.96-1.77), and the lowest was smoking variable with PR value = $e^{1.05}$ = 2.857 (95% CI– 0.69-1.41).

Efforts that can be made in preventing or minimizing the incidence of hypertension are by maintaining a diet such as a salt-free diet and a sugar-free diet, maintaining a lifestyle by doing regular exercise and getting enough sleep, creating a relaxed state in every activity carried out, and avoiding places that have a high risk of air pollution. Meanwhile, health workers and those who have the authority related to the prevention of hypertension can conduct counseling and education about hypertension and how to prevent it

Compliance with ethical standards

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Disclosure of Conflict of interest

The authors assert that they have no competing interests.

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