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DETERMINANTS OF PREHYPERTENSION AND HYPERTENSION AMONG INDONESIAN PRODUCTIVE-AGE POPULATION USING ORDINAL LOGISTIC REGRESSION WITH NON-PROPORTIONAL ODDS MODEL

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ABSTRACT

Non-communicable diseases (NCDs) account for the majority of deaths in Indonesia, especially cardiovascular diseases. The main risk factor for cardiovascular disease is hypertension, which is also an NCDs with the highest increase in prevalence compared to other NCDs. The risk of cardiovascular disease doubles for every increase in blood pressure of 20/10 mmHg and starts from a pressure of 115/75 mmHg. Therefore, a prehypertension category was introduced which also aims to prevent the development of hypertension. The prevalence of hypertension in the majority of the productive-age population (15─64 years) has exceeded the RPJMN 2015─2019 target even though Indonesia is currently in the demographic bonus period.

This research aims to obtain a general picture and factors influencing blood pressure status among the productive-age population in Indonesia in 2018. The data used comes from Riskesdas, integrated with Susenas in 2018. The results of the ordinal logistic regression analysis (non-proportional odds model) show that consumption of fruit and vegetables, consumption of fatty foods, consumption of salty foods, consumption of seasonings, alcohol consumption, smoking status, physical activity, education level, employment status, poverty status, residence, age, gender, and body mass index have a significant effect on blood pressure status in the productive-age population.

Studies on prehypertension and hypertension simultaneously in the productive-age population (15─64 years) in Indonesia have not been conducted. Several studies regarding prehypertension and hypertension have been carried out using the multinomial logistic regression method. However, blood pressure classification is based on a combination of systolic and diastolic blood pressure, so it needs to be treated as an ordinal category. Other studies using ordinal logistic regression methods only focused on the severity of hypertension without involving the categories of normal and prehypertension. In fact, the inclusion of these two categories is necessary to determine the risk factors that contribute to changes in blood pressure from the normal category to prehypertension and prehypertension to hypertension.

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1. INTRODUCTION

One indicator that measures community welfare is health. Issues regarding health are included in the third goal of the Sustainable Development Goals, which is ensuring healthy lives and improving the welfare of all people at all ages. This is in line with the 2020─2024 Preliminary Draft of the National Medium-Term Development Plan which includes an agenda for improving the quality and competitiveness of human resources through improving health status [1]. Currently, Indonesia is facing an epidemiological transition characterized by a decrease in the contribution of morbidity and mortality caused by infectious diseases as the main burden and being replaced by non-communicable diseases [2].

Non-communicable diseases (NCDs) are diseases that cannot be transmitted from person to person and whose development occurs slowly over a long time [3]. World Health Organization (WHO) estimates that NCDs contributed to 73 percent of all deaths in 2016 in Indonesia, with the largest proportion being cardiovascular disease (35 percent) [4]. The prevalence of NCDs in Indonesia is generally increasing. However, hypertension experienced the highest increase in prevalence compared to other NCDs, namely from 25.8 percent in 2013 to 34.1 percent in 2018 [5]. In most of the population of productive age (15 - 64 years), this prevalence has also exceeded the 2015─2019 Preliminary Draft of the National Medium-Term Development Plan target of 23.4 percent [6]. In fact, Indonesia is currently enjoying a demographic bonus period, which is the dominance of the productive-age population, whose peak is expected to occur in the period 2020─2035 [7]. Apart from being an NCD, hypertension is also one of the main risk factors for the development of cardiovascular disease, cerebrovascular disease, peripheral arterial disease, aortic aneurysm, and chronic kidney disease [8].

The level of risk of cardiovascular disease will increase even with a slight increase of blood pressure which is beginning at 115/75 mmHg [9], [10]. This risk doubles for every 20/10 mmHg increase in blood pressure [10]. Therefore, the prehypertension category was introduced which falls between the normal and hypertension stage I categories [10]. Prehypertension is not considered as a disease, but an indicator to identify potential hypertension so that the rate of development of blood pressure can be controlled through healthy lifestyle interventions [10].

Studies regarding prehypertension and hypertension simultaneously in the productive age population (15 - 64 years) in Indonesia have not been conducted. Several studies on prehypertension and hypertension [11] - [16] have been carried out using the multinomial logistic regression method. However, blood pressure classification is based on a combination of systolic and diastolic blood pressure, so it needs to be treated as an ordinal category. Another study that used the ordinal logistic regression method only focused on the severity of hypertension without involving the normal and prehypertension categories [17]. In fact, the inclusion of these two categories is necessary to determine the risk factors that contribute to changes in blood pressure from the normal category to prehypertension and prehypertension to hypertension. Therefore, this study aims to determine the general picture and risk factors that influence prehypertension and hypertension in the productive population (15 - 64 years) in Indonesia using ordinal logistic regression.

2. METHODS

The results of blood pressure measurements consist of two numbers. The systolic BP number represents the pressure when the heart contracts or beats, while the diastolic BP number represents the pressure when the heart rests between heartbeats [18]. Blood pressure classification for people aged < 18 years is based on The Fourth Report on The Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents [19], while for people aged ≥ 18 years is based on The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [10].

Table 1. Blood Pressure Classification

Category	Age < 18 years old	Age ≥ 18 years old	
	Systolic and/or Diastolic Pressure (mmHg)	Systolic Pressure	Diastolic Pressure
Normal	< 90th percentile (and)	< 120	and < 80
Prehypertension	90th until < 95th percentile (or)	120─139	or 80─89
Hypertension Stage I	95th until 99th percentile + 5 mmHg (or)	140─159	or 90─99
Hypertension Stage II	> 99th percentile + 5 mmHg (or)	≥ 160	or ≥ 100

The Directorate General of Disease Prevention and Control through 2015─2019 National Action Plan for Prevention and Control of Non-Communicable Diseases [20] states that one of the global strategies for dealing with NCDs is the prevention of risk factors and early detection through cost-effective and comprehensive case management in health facilities. These risk factors include non-modifiable risk factors, modifiable risk factors (behavioral and environmental), and physiological risk factors [20]. Arifin *et al.* [21] modified the framework and found that all four risk factors influenced NCDs, including hypertension.

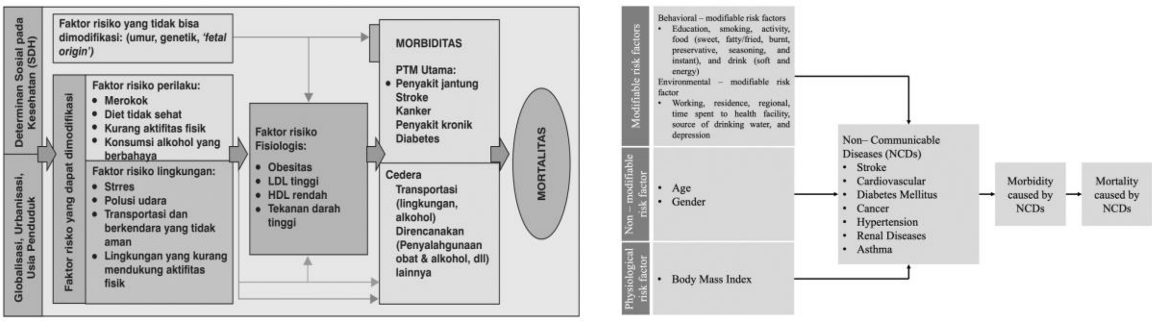

Figure 1. NCD Risk Factors Framework according to Ministry of Health (2017) and Arifin, et al. (2022)

Material and Data

The research data comes from the 2018 Basic Health Research (Riskesdas) released by Kementerian Kesehatan (Ministry of Health) and integrated with the March 2018 National Socio-Economic Survey (Susenas) in March 2018 conducted by Badan Pusat Statistik (Statistics Indonesia) [5], [22]. Susenas was carried out using two stage sampling using the probability proportional to size method using linear systematic sampling [5], [22]. The target sample visited was 300,000 households from 30,000 Susenas census blocks [5], [22]. The 2018 Riskesdas data collection was carried out through interviews, measurements, and examinations in 2,500 census blocks in 26 provinces by a team of data collectors and community health center health workers of around 10,000 people with a minimum educational qualification of D-3 in health for interviewers, dentists for dental and oral examiners, and nurses to take blood samples under the coordination of more than 400 district/city and provincial technical responsibilities [5], [22]. The unit of analysis for this research was the population of productive age (15─64 years) who had their blood pressure measured, which was 560,531 people. The dependent and independent variables used in this research are explained in Table 2.

Table 2. Research Variables

Variables	Category	Source and Reference
Blood Pressure Status (Y)	Normal (*ref.*) Prehypertension Hypertension Stage I Hypertension Stage II	[5], [10], and [19]

Modifiable risk factors (behavioral)		
Consumption of Fruit and Vegetables (X_1)	Sufficient (*ref.*) Insufficient	[5], [15], and [23]
Consumption of Fatty Foods (X_2)	Infrequent (*ref.*) Frequent	[3], [24], and [25]
Consumption of Salty Foods (X_3)	Infrequent (*ref.*) Frequent	[3], [11], [26], and [27]
Consumption of Seasonings (X_4)	Infrequent (*ref.*) Frequent	[3], [28], and [29]
Consumption of Alcohol (X_5)	No (*ref.*) Yes	[5] and [11]
Smoking Status (X_6)	No (*ref.*) Yes	[5], [11], [13], and [16]
Physical Activity (X_7)	Active (*ref.*) Less Active	[5], [13], and [30]
Modifiable risk factors (environment)		
Education Level (X_8)	≥ High school (*ref.*) < High school	[11], [15], [31], and [32]
Employment Status (X_9)	Not working (*ref.*) Working	[15] and [33]
Poverty Status (X_{10})	Not poor (*ref.*) Poor	[12], [32], and [34]
Residence (X_{11})	Rural (*ref.*) Urban	[15], [32]
Non-modifiable risk factors		
Age (X_{12})	Numeric	[12], [14], [15], and [16]
Sex (X_{13})	Female (*ref.*) Male	[13], [14], [15]
Physiological risk factors		
BMI (X_{14})	Underweight (*ref.*) Normal Overweight/obesity	[12], [14], [15], [16], and [35]

Research Method

Descriptive analysis was used to find out a general picture of the blood pressure status of the productive age population in Indonesia using tables and graphs. Meanwhile, inferential analysis was used to determine the risk factors that influence the blood pressure status of the productive age population in Indonesia using ordinal logistic regression. The significance level used is 5 percent. The stages of inferential analysis are as follows.

1. Parameter estimation of proportional odds model (POM)
   The estimation of POM parameters is performed using Maximum Likelihood Estimation (MLE), which maximizes the likelihood function by deriving the natural logarithm of the likelihood function in the proportional odds model (POM) [36].
2. Testing the parallel lines assumption
   The parallel lines assumption test aims to assess the equality of regression coefficients (slopes) of the independent variables across all logit models [37], [38]. The hypothesis used in the parallel lines' assumption test is $H_0: \beta_{1k} = \beta_{2k} = \cdots = \beta_{(J-1)k} = \beta; k = 1,2,\ldots,p$ (the regression coefficients of the k-th independent variable are the same for all models). If the result of the parallel lines assumption test using the Brant-Wald Test [39] leads to the rejection of the null hypothesis globally or partially when $p - value < \alpha$, it can be concluded that there is independent variable

with different regression coefficients, or the parallel lines assumption is not met. When only some of the independent variables meet this assumption, the partial proportional odds model (PPOM) can be applied. However, when none of the independent variables meet this assumption, the non-proportional odds model (NPOM) can be applied [37], [40], [41].

3. Parameter estimation of non-proportional odds model (NPOM)
   The estimation of NPOM parameter is performed using MLE which maximizes the likelihood function by decreasing the natural logarithm of the likelihood function in NPOM [37].
4. Modeling the non-proportional odds model (NPOM)
   One of the most frequently used ordinal logistic regression models that is easier to apply and interpret is cumulative logit. Cumulative probability of NPOM for j-th category with α_j as the intercept of j-th category, β_j as the vector of regression coefficients for the independent variables of j-th category, and x' as the vector of independent variables is as follows [37], [40], [41].
   $$P(Y > j) = \frac{expexp\,(\alpha_j + x'\beta_j)}{1 + expexp\,(\alpha_j + x'\beta_j)}; j = 1,2, \dots, J-1 \quad (1)$$
5. Testing the significance of parameters
   Parameter significance tests are carried out simultaneously and partially. The simultaneous test serves to determine the effect of the independent variables together on the dependent variable. The hypothesis used in the simultaneous test is $H_0 : \beta_1 = \beta_2 = \cdots = \beta_p = 0$ (no independent variables have a significant effect on blood pressure status). If the simultaneous test results with the Likelihood Ratio Test result in a reject decision H_0 when $G > \chi^2_{\alpha(p)}$ or $p - value < \alpha,$ it can be concluded that there is at least one independent variable that has a significant effect on the dependent variable [36]. Apart from that, the partial test serves to determine the effect of each independent variable coefficient on the dependent variable. The hypothesis used in the partial test is $H_0 : \beta_k = 0; k = 1,2, \dots, p$ (the k-th independent variable has no significant effect on the dependent variable). If the partial test results with the Wald Test result in a reject decision H_0 when $W_k^2 > \chi^2_{\alpha(1)}$ or $p - value < \alpha,$ it can be concluded that the independent variable has a significant effect on the dependent variable [36].
6. Calculation of the odds ratio
   Calculating the odds ratio obtained shows the association or the magnitude of the tendency of the influence of the independent variable on the dependent variable, specifically comparing subjects with $x = 1$ to subjects with $x = 0$ or for everyone unit increase in x. This value is obtained by exponentiating the regression coefficient of each independent variable [36].

3. RESULTS

Descriptive Analysis

In FIGURE 2, it can be seen that the majority of the Indonesian productive age population (15─64 years) in 2018 had blood pressure at prehypertension level (39.6 percent). In addition, the proportion of people who experience hypertension is higher than people who have a normal category (31.18 percent). Even though the proportion of hypertension is lower than prehypertension, this condition has exceeded the hypertension prevalence target based on the 2015─2019 Preliminary Draft of the National Medium-Term Development Plan, which is 23.4 percent [6]. Table 3 shows a general description of the productive age population based on blood pressure status and characteristics.

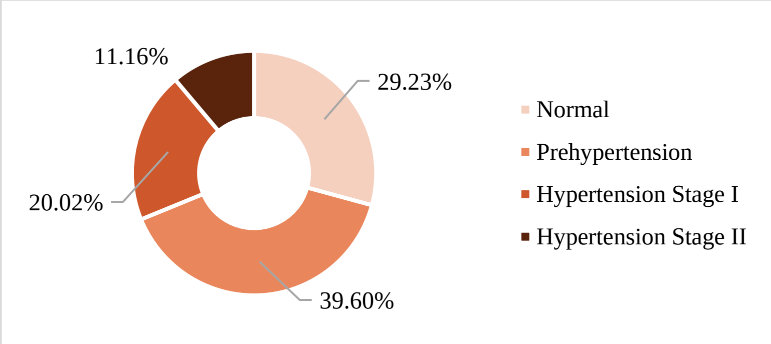

Figure 2. Percentage of Blood Pressure Status in the Productive-Age Population

Table 3. General Description of the Productive-Age Population Based on Blood Pressure Status and Characteristics

Independent Variables	Category	Blood Pressure Status (%) Normal	Prehypertension	Hypertension Stage I	Hypertension Stage II	Total (%)
Modifiable risk factors (behavioral)						
Consumption of Fruit and Vegetables (X_1)	Sufficient	30.10	39.14	19.68	11.08	9.97
	Insufficient	29.13	39.65	20.05	11.17	90.03
Consumption of Fatty Foods (X_2)	Infrequent	29.12	40.32	19.76	10.80	57.83
	Frequent	29.37	38.61	20.36	11.66	42.17
Consumption of Salty Foods (X_3)	Infrequent	29.65	39.60	19.73	11.01	70.65
	Frequent	28.20	39.58	20.70	1152	29.35
Consumption of Seasonings (X_4)	Infrequent	29.05	40.45	19.82	10.68	21.66
	Frequent	29.28	39.36	20.07	11.29	78.34
Consumption of Alcohol (X_5)	No	29.14	39.50	20.05	11.31	96.09
	Yes	31.40	41.97	19.24	7.40	3.91
Smoking Status (X_6)	No	30.22	36.69	20.41	12.68	61.42
	Yes	27.65	44.21	19.40	8.75	38.58
Physical Activity (X_7)	Active	28.15	40.29	20.16	11.40	72.27
	Less Active	32.02	37.79	19.64	10.55	27.73
Modifiable risk factors (environment)						
Education Level (X_8)	≥ High school	32.05	41.91	17.65	8.39	38.89
	< High school	27.43	38.13	21.52	12.92	61.11

Employment Status (X_9)	Not working	35.05	33.45	19.84	11.66	35.32
	Working	26.04	42.95	20.11	10.89	64.68
Poverty Status (X_{10})	Not poor	29.11	39.58	20.10	11.22	92.99
	Poor	30.79	39.82	18.97	10.42	7.01
Residence (X_{11})	Rural	28.59	40.79	19.96	10.66	44.32
	Urban	29.73	38.65	20.06	11.56	55.68
Non-modifiable risk factors						
Age (X_{12})	Numeric					
Sex (X_{13})	Female	31.39	34.86	20.06	13.69	49.19
	Male	27.13	44.18	19.97	8.72	50.81
Physiological risk factors						
Body Mass Index (BMI) (X_{14})	Underweight	53.58	30.43	11.87	4.11	10.28
	Normal	32.66	42.03	17.71	7.61	55.56
	Overweight/ obesity	16.32	38.40	26.22	19.06	34.17

In terms of behavioral risk factors, the percentage of the productive-age population experiencing prehypertension is higher in people who consume fruit and vegetables insufficiently, consume fatty foods and seasonings infrequently, drink alcohol, smoke, and are physically active. In addition, the percentage of the people experiencing hypertension stage I and stage II are higher among people who consume fruit and vegetables insufficiently, consume fatty foods, salty foods, and seasonings frequently, do not drink alcohol, do not smoke, and are physically active. This indicates that habits, behavior, and lifestyle affect blood pressure status of the productive-age population.

In terms of environmental risk factors, the percentage of the productive-age population experiencing prehypertension is higher among people with a high school education or above, working, poor, and living in rural areas. Apart from that, the percentage of the people experiencing hypertension stage I and stage II are higher among people with junior high school education or below, do not work, are poor, and live-in urban areas. This indicates that environment, education, and economics influence the blood pressure status of the productive-age population.

In terms of factors that cannot be modified, the percentage of the productive-age population experiencing normal and prehypertension are higher in the younger people, while the percentage of the people experiencing hypertension stage I and stage II are higher in the older people. In addition, the percentage of the people experiencing prehypertension is higher in the male population. The percentage of the male and female experiencing hypertension stage I is relatively the same, but the percentage of the female experiencing hypertension stage II is higher than male. This happens because most women who experience hypertension stage II are in the perimenopause and menopause period, so they begin to lose the hormone estrogen which has a protective effect. This indicates that age and gender influence the blood pressure status of the productive-age population.

In terms of physiological factors, the percentage of the productive-age population experiencing prehypertension is higher in people with normal BMI. In addition, the percentage of the people experiencing hypertension stage I and stage II are higher in overweight/obese people. This shows that nutritional status influences the blood pressure status of the productive-age population.

Inferential Analysis

Estimation of ordinal logistic regression parameters with proportional odds model (POM) was carried out with MLE. The global Brant-Wald Test produces a chi-square of 12,712.18 which is more than $\chi^2_{(0,05;30)} = 43{,}77$ and a p-value of 0.000. In addition, the Brant Test for each independent variable produces a chi-square of more than $\chi^2_{(0,05;2)} = 5{,}99$ and a p-value of less than 5 percent. Thus, the parallel lines assumption is not met globally and partially so that the non-proportional odds model (NPOM) can be applied, and its parameters estimated. The simultaneous parameter significance test produced a chi-square of 118,230.53 and a p-value of 0.000, so there is at least one independent variable that has a significant effect on the blood pressure status of the productive-age population. The partial parameter significance test results are presented in Table 4.

Table 4. NPOM Parameter Estimation Results

	Independent Variables	Coeff.	*Std. Error*	*Odds Ratio*	*p-value*
Mod el I $logit[P$ $Norma$	Consumption of Fruit and Vegetables (Insufficient)	0.1097	0.00991	1.1160	0.000*
	Consumption of Fatty Foods (Frequent)	-0.0551	0.00676	0.9464	0.000*
	Consumption of Salty Foods (Frequent)	0.0970	0.00757	1.1019	0.000*
	Consumption of Seasonings (Frequent)	0.0072	0.00727	1.0072	0.322
	Consumption of Alcohol (Yes)	0.0732	0.01490	1.0760	0.000*
	Smoking Status (Yes)	-0.2451	0.00973	0.7826	0.000*
	Physical Activity (Less Active)	0.0116	0.00721	1.0117	0.106
	Education Level (< High school)	0.1025	0.00679	1.1079	0.000*
	Employment Status (Working)	0.0057	0.00743	1.0057	0.444
	Poverty Status (Poor)	-0.0208	0.01163	0.9794	0.074
	Residence (Urban)	-0.0612	0.00656	0.9407	0.000*
	Age	0.0429	0.00027	1.0438	0.000*
	Sex (Male)	0.5152	0.00936	1.6740	0.000*
	BMI (Normal)	0.7235	0.00986	2.0616	0.000*
	BMI (Overweight/obesity)	1.5719	0.01123	4.8157	0.000*
	Intercept	-1.8635	0.01749		0.000*
	Consumption of Fruit and Vegetables (Insufficient)	0.0578	0.00973	1.0595	0.000*
	Consumption of Fatty Foods (Frequent)	0.0222	0.00662	1.0224	0.001*
	Consumption of Salty Foods (Frequent)	0.0714	0.00734	1.0740	0.000*
	Consumption of Seasonings (Frequent)	0.0513	0.00711	1.0527	0.000*
	Consumption of Alcohol (Yes)	0.1681	0.01501	1.1831	0.000*
	Smoking Status (Yes)	-0.2845	0.00930	0.7524	0,000*
	Physical Activity (Less Active)	0.1070	0.00712	1.1129	0,000*
	Education Level (< High school)	0.2590	0.00691	1.2956	0,000*
	Employment Status (Working)	-0.2760	0.00734	0.7588	0,000*
	Poverty Status (Poor)	-0.0542	0.01192	0.9472	0,000*
Mod el II	Residence (Urban)	0.0372	0.00643	1.0379	0,000*
	Age	0.0458	0.00025	1.0468	0,000*
	Sex (Male)	0.2073	0.00913	1.2303	0,000*
	BMI (Normal)	0.4267	0.01249	1.5323	0,000*
	BMI (Overweight/obesity)	1.1912	0.01282	3.2910	0,000*
	Intercept	-3.4100	0.01944		0,000*

logit[*P*
Prehyp

Mod el III *logit*[*P*(*Hyperte*	Consumption of Fruit and Vegetables (Insufficient)	0.0514	0.01382	1.0527	0.000*
	Consumption of Fatty Foods (Frequent)	0.0380	0.00938	1.0387	0.000*
	Consumption of Salty Foods (Frequent)	0.0558	0.01044	1.0574	0.000*
	Consumption of Seasonings (Frequent)	0.0820	0.01019	1.0854	0.000*
	Consumption of Alcohol (Yes)	0.1445	0.02376	1.1554	0.000*
	Smoking Status (Yes)	-0.2614	0.01368	0.7699	0.000*
	Physical Activity (Less Active)	0.1122	0.01012	1.1188	0.000*
	Education Level (< High school)	0.2269	0.01021	1.2547	0.000*
	Employment Status (Working)	-0.2662	0.01015	0.7663	0.000*
	Poverty Status (Poor)	-0.0180	0.01754	0.9822	0.305
	Residence (Urban)	0.0411	0.00915	1.0419	0.000*
	Age	0.0639	0.00038	1.0660	0.000*
	Sex (Male)	-0.0139	0.01330	0.9862	0.297
	BMI (Normal)	0.4261	0.02145	1.5313	0.000*
	BMI (Overweight/obesity)	1.2913	0.02144	3.6380	0.000*
	Intercept	-5.5996	0.03180		0.000*

*) Significant at a significance level of 5 percent

Based on the estimation results in Table 4, three models were formed, namely cumulative logit for minimum prehypertension compared with normotension (model I), cumulative logit for minimum hypertension stage I compared with maximum prehypertension (model II), and cumulative logit for hypertension stage II compared with maximum hypertension stage I (model III).

4. DISCUSSIONS

Productive-age people who insufficiently consume fruit and vegetables have a risk of 1.116 times experiencing at least prehypertension, 1.0595 times experiencing at least hypertension stage I, and 1.0527 times experiencing hypertension stage II compared to people who sufficiently consume them, assuming other variables are constant. Li *et al.* [23] and Ismail *et al.* [15] revealed that a higher frequency of fruit and vegetable consumption has a lower risk of developing hypertension. Li *et al.* [23] also stated that fruit and vegetable content help reduce blood pressure through improving endothelial function, modulating baroreflex sensitivity, vasodilation, and antioxidant activity.

Productive-age people who frequently consume fatty foods have a risk of at least 1.0224 times experiencing hypertension stage I and 1.0387 times experiencing hypertension stage II compared to people who infrequently consume them, assuming other variables are constant. Yuan *et al.* [25] found that high fat consumption increases the risk of hypertension. This high-fat diet causes inactivation of nitric oxide (NO) which stimulates arteriole dilation and contributes to oxidative stress and endothelial dysfunction [24].

Productive-age people who frequently consume salty foods have a risk of 1.1019 times experiencing at least prehypertension, 1.0740 times experiencing at least hypertension stage I, and 1.0574 times experiencing hypertension stage II compared to people who infrequently consume them, assuming other variables are constant. This result is similar to research by Mahanta *et al.* [11]. High salt intake is associated with water retention, increased systemic peripheral resistance, functional changes in the vascular endothelium, changes in arterial structure and function as well as modifications in sympathetic and autonomic nervous activity [27]. Stiffness of arteries and arterioles can be triggered by a high-salt diet which encourages changes in blood vessel smooth muscle cells resulting in a buildup of collagen in the walls of large arteries [26].

Productive-age people who frequently consume seasonings have a risk of 1.0527 times experiencing at least hypertension stage I and 1.0854 times experiencing hypertension stage II compared to people who infrequently consume them, assuming other variables are constant. Rusmevichientong *et al.* [29] revealed that people who often buy ready-to-eat food, eat out, or use stock cubes/MSG when preparing food are at higher risk of developing hypertension. In addition, MSG intake was positively related to changes in systolic and diastolic blood pressure over five years.

Productive-age people who consume alcohol have a risk of 1.0760 times experiencing at least prehypertension, 1.1831 times experiencing at least hypertension stage I, and 1.1554 times experiencing hypertension stage II compared to people who do not consume alcohol, assuming other variables are constant. Mahanta *et al.* [11] also found the same thing. This is thought to be related to endothelial dysfunction, vasoconstriction, activation of the sympathetic nervous system, and activation of the renin-angiotensin-aldosterone system (RAAS) [42].

Productive-age people who smoke have a risk of 0.7826 times to experience at least prehypertension, 0.7524 times experiencing at least hypertension stage I, and 0.7699 times experiencing hypertension stage II compared to people who do not smoke, assuming other variables are constant. This finding is contrary to [11], [13], and [16] because smokers are at higher risk of developing prehypertension and hypertension. Several studies [43], [44] show that the role and mechanisms of smoking as a risk factor for hypertension are still unclear and may be related to other factors, such as genetic susceptibility.

Productive-age people who are less physically active have a risk of 1.1129 times of experiencing at least hypertension stage I and 1.1188 times experiencing hypertension stage II compared to people who are not physically active, assuming other variables are constant. Choi *et al.* [13] stated that people who are active, such as having regular exercise habits and doing vigorous physical activity, have a lower risk of developing prehypertension and hypertension. This effect is thought to be related to a decrease in cardiac output, sympathetic nervous system, renin-angiotensin system (RAS) activity, total peripheral vascular resistance, and insulin resistance as well as increased endothelial function [30].

Productive-age people who have a junior high school education or below has a risk of 1.1079 times experiencing at least prehypertension, 1.2956 times experiencing at least hypertension stage I, and 1.2547 times experiencing of hypertension stage II compared to people who have a high school education or above, assuming other variables are constant. Mahanta *et al.* [11], Ismail *et al.* [15], and Rahut *et al.* [32] explained that people with lower education are at higher risk of developing hypertension than people with higher education. A low level of education is often associated with low health literacy and awareness of hypertension [15].

Productive-age people who work have a risk of 0.7588 times experiencing at least hypertension stage I and 0.7663 times experiencing hypertension stage II compared to people who do not work, assuming other variables are constant. This finding is in line with [15] which states that people who do not work are at higher risk of developing hypertension than people who work. Manrique-Acevedo *et al.* [33] found that men who do not work for a long time have a higher risk of developing hypertension, while women who do not work have a higher risk of developing obesity. People who work do physical activities that require energy, unlike people who do not work [45].

Productive-age people who are poor have a risk of 0.972 times higher risk of experiencing at least hypertension stage I compared to people who are not poor, assuming other variables are constant. This result is in line with [12] and [32] which was in developing countries, the middle and upper classes population is at higher risk of developing hypertension than the lower class. People with higher socioeconomic status in low- and middle-income countries have sedentary lifestyles. This group can afford more consumable resources and tends to consume more food calories which leads to overweight and hypertension [12].

Productive-age people who live in urban areas have a risk of 1.0379 times experiencing at least hypertension stage I and 1.0419 times experiencing hypertension stage II compared to rural residents. Rahut *et al.* [32] also found something similar. This is related to the lifestyle of rural residents who tend to consume less salt, have lower levels of obesity, and experience fewer cases of hypertension [46].

Productive-age people who are one year older have a risk of 1.0438 times experiencing at least prehypertension, 1.0468 times experiencing at least hypertension stage I, and 1.0660 times experiencing hypertension stage II, assuming other variables are constant. Al Kibria *et al.* [12], Rahman *et al.* [14], Ismail *et al.* [15], and Sudikno *et al.* [16] also stated the same thing. The increase in blood pressure with age is related to stiffness of the arteries and arterioles caused by the structural changes of arteriosclerosis and calcification. As a result, there is an earlier reflection of the pressure wave from the arterioles towards the heart during the propagation of the blood pressure wave. This pressure wave returns when the heart contracts, causing an increase in central systolic pressure and widening the pulse pressure [26].

The productive-age male is 1.6740 times more likely to experience at least prehypertension and 1.2303 times more likely to experience at least hypertension stage I compared to the female, assuming other variables are constant. This result is in line with [13] ─ [15] which states something similar. The female hormone estrogen causes vasodilation and increases nitric oxide (NO) synthase or signaling, while androgen hormones, such as testosterone, can affect the renin-angiotensin system (RAS) which leads to increased sodium reabsorption and renal vasoconstriction [47].

Productive-age people who are overweight/obese have a risk of 4.8157 times experiencing at least prehypertension, 3.2910 times experiencing at least hypertension stage I, and 3.6380 times experiencing hypertension stage II compared to underweight people, assuming other variables are constant. Al Kibria *et al.* [12], Rahman *et al.* [14], Ismail *et al.* [15], and Sudikno *et al.* [16] also found something similar. Activation of the sympathetic nervous system, the amount of intra-abdominal and intravascular fat, sodium retention which causes increased renal reabsorption, and activation of the renin-angiotensin system (RAS) play a role in the pathogenesis of hypertension [48]. An increase in body size also leads to an increase in blood volume and cardiac output which channels blood to additional adipose tissue, which is endocrine tissue that is active and produces chemicals, including leptin which triggers high blood pressure [49].

5. CONCLUSION

Most of the productive-age population is at prehypertensive BP level. In model II (productive-age population with at least hypertension stage I), consumption of fruit and vegetables, fatty foods, salty foods, seasonings, and alcohol, smoking status, physical activity, education level, employment status, poverty status, residence, age, gender, and BMI have a significant effect. However, in model I (productive-age population with at least prehypertension), it is not influenced by consumption of seasonings, physical activity, employment status, and poverty status. In model III (productive-age population with hypertension stage II), it is not influenced by poverty status and gender.

Productive-age people are encouraged to carry out regular blood pressure checks and monitoring. Even though prehypertension is not considered as a disease, people with prehypertension status must adopt a healthier lifestyle so that blood pressure does not develop to the level of hypertension stage I. This also applies to people with hypertension stage I so that blood pressure does not develop to the level of hypertension stage II. If lifestyle changes are not effective enough to maintain or reduce blood pressure, further examination and diagnosis by a health professional is necessary. The government also needs to expand access to education and employment opportunities and continue to intensify health promotion and education regarding prehypertension and hypertension so that public health literacy can increase, and the prevalence of hypertension can decrease.

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