Longitudinal Study of Systolic and Diastolic Blood Pressure among Hypertension Population Aged 26-59 years in West Java Province, Indonesia

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Abstract

Background: The untreated and/or uncontrolled hypertension will be dangerous, because of the leading cause of the increasing morbidity and mortality. Other determinant factors for reducing blood pressure besides antihypertensive medication are expected to have an impact on the hypertensive population, but little has been achieved in the understanding of dynamics of changes in blood pressure on a population level.

Objective: To investigate the dynamics of changes in systolic and diastolic blood pressure among hypertension population aged 26-59 in Kebon Kalapa Village, West Java Province, Indonesia for 3 years' observation (year 2015-2017).

Methods: This study used secondary data from the 'Cohort Study of Non-Communicable Disease Risk Factors' conducted in Kebon Kalapa Village-West Java Province in 2015-2017. The population in this study was taken from individuals with hypertension wherein year the 2015 aged 26 to 59 years, and total sample obtained for analysis was 208 respondents.

Results: In This study, 87% hypertensive people were pre-elderly. The variable of age, BMI, sodium intake and stress the simultaneous influence of SBP and DBP changes ($p<0.05$). The increasing age of 1 year will increase DBP of hypertensive people aged 26-59 years by 1 mmHg after multivariable adjustment. Meanwhile, the increase of SBP by age could not statistically be predicted by fixed effects regression models. The magnitude association between BMI and blood pressure shown a one unit BMI increase was associated with 2,47mmHg SBP and 1.03mmHg DBP after multivariable adjustment.

Conclusion: For Indonesian, our analysis suggests for including the information about the BMI changes in the hypertension monitoring reports, as indicators of early awareness of risk factors and prognostic factors for increased blood pressure.

Keywords: *longitudinal, systolic, diastolic, hypertension.*

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Introduction

Hypertension (HT) known as high blood pressure, is a condition in which the systolic blood pressure equal to or above 140 mm Hg and/or diastolic blood pressure equal to or above 90 mm Hg[1]. The untreated and/or uncontrolled HT will be dangerous, because of the leading cause of the increase of cardiovascular risk,

onset of vascular and renal damage, and mortality[2]. The number of important causal factors for HT complication have been identified, such as obesity, excess sodium intake, unhealthy diet, family history of hypertension and low socioeconomic status[3,1].

Worldwide, hypertension is estimated to cause 7.5 million deaths, about 12.8% of the total of all deaths. Complications of hypertension account for 9.4 million deaths worldwide every year. Hypertension is responsible for at least 45% of deaths due to heart disease, and 51% of deaths due to stroke[1]. In Indonesia, prevalence of hypertension increased from 25.8% in 2013 to 34.1% in 2018. The prevalence of hypertension is highly age dependent. A prevalence of 13.2percent among adults 18–24 years of age rises to 45.3percent among pre-elderly[4]. Hypertension and its complications are the 5th leading cause of death for all ages in Indonesia[5].

Treating systolic and diastolic blood pressure to achieve the normal level is associated with a decrease in cardiovascular disease complication. In the clinical trial study, antihypertensive therapy has been associated with reduction in heart failure (averaging more than 50%), stroke incidence (averaging 35-40%), and myocardial infraction (averaging 20-25%). It is estimated that in patients with stage one hypertension and additional cardiovascular risk factors, achieving a sustained 12 mmHg reduction in systolic blood pressure over 10 years will prevent 1 death for every 11 patients treated. In the added presence of cardiovascular disease or target organ damage, only 9 patients would require such blood pressure reduction to prevent 1 death[3].

Other determinant factors for reducing blood pressure besides antihypertensive medication are expected to have an impact on the hypertensive population, but little has been achieved in understanding of dynamic of changes in blood pressure on a population level. In Indonesia, longitudinal study that focuses on the dynamics of changes in blood pressure in a hypertensive population as a treatment strategy for controlling blood pressure is not much. The objective of study was to investigate the dynamics of changes in systolic and diastolic blood pressure among hypertension population aged 26-59 in Kebon Kalapa Village, West Java Province, Indonesia for 3 years' observation (year 2015-2017).

Methods

This study used secondary data from the 'Cohort Study of Noncommunicable Disease Risk Factors' conducted by the National Institute of Health Research and Development, Indonesian Ministry of Health in Kebon Kalapa Village-West Java Province in 2015 until 2017. The population in this study was taken from individuals with hypertension where in the year 2015 aged 26 to 59 years who enrolled in the cohort study (N = 389). The reproductive woman who used hormonal contraception (n = 131) and whose data were not available at the follow-up in three years (missing data, n = 50) were excluded from the study sample. Thus, the total number of individuals included in this study was 208.

Hypertension status assessed through systolic blood pressure (SBP) ≥140 mmHg, and/or diastolic blood pressure (DBP) ≥ 90 mmHg, and/or diagnosis of hypertension by a health professional, and/or undergoing treatment for hypertension. Blood pressure (SBP and DBP) was considered as the dependent variable. The number of SBP/DBP are mean by double measuring the SBP/DBP within 5 minutes under appropriate condition. The independent factors were age, nutritional status, sodium dietary intake, and mental health status/stress. Sodium dietary intake was obtained using 24-hour recall. The nutritional status was measured with a body mass index (BMI) parameter. BMI was calculated as body weight in kilograms divided by the height in meters squared. Mental health status/stress assessed using a self-report questionnaire. Data processing involved cleaning and transforming data and was performed by univariate, bivariate using ANOVA or Friedman test, and multivariate using panel data regression.

Results

The characteristic of adult and pre-elderly with hypertension

The sociodemographic, health and nutrition characteristic among hypertensive adult (aged 26-44years) and hypertensive pre-elderly (aged 45-59years) in the first observation (year 2015) present in Table 1. The result shown that pre-elderly has the highest proportion of hypertension population (87%) compared to adult (13%). Generally, characteristic among hypertensive adult and hypertensive pre-elderly are similar, where most of them are female, employment, obese, diastolic blood pressure above 90 mmHg, sodium intake was normal, and not stress. Meanwhile, for the level of education and systolic blood pressure show different. Most of hypertensive adult had higher

education and systolic blood pressure below 140 mmHg, but characteristic of hypertensive pre-elderly show vice versa.

The observational data on SBP, DBP, BMI, sodium dietary intake and mental health for three years (year 2015-2017) presented in Table 2. It was shown that all means of SBP were above 140mmHg, all means of DBP were above 90 mmHg, all means of BMI were in the overweight category (>25kg/m^2), all of SRQ score means were less than 6 (in not stress category), and means of sodium intake in the year 2015 until 2016 shown ≤ 2300mg/d (normal sodium intake), while in the year 2017 the mean shown >2300mg/d (excessive sodium intake). The mean difference between time observation was proved statistically significant only for variable DBP, sodium intake and scores of SRQ (p value <0.05).

The pattern of SBP and DBP changes

The pattern of SBP among the hypertensive population, according to age shown tendency to increase with age. The mean SBP was 127.42mmHg among hypertensive people aged 26-30 years, and the mean SBP increase to 151.05 mmHg in hypertensive people aged 61-65years. Whereas for the mean DBP seen to increase until the age of 41-45 years (97.51 mmHg) and thereafter seen to decrease to 91.26mmHg in aged 61-65years (Picture 1.a). According to BMI level, the pattern of SBP and DBP changes tend to increase with increasing BMI level (Picture 1.b). Mean SBP and DBP in lean hypertensive people were 142.04mmHg and 82.86mmHg respectively. The highest mean SBP and DBP were seen among obese hypertensive people, i.e. 150.23 mmHg and 95.86mmHg respectively. The similar pattern was also seen in DBP changes according to sodium dietary intake, which tendency to increase with increasing amount of sodium dietary intake, meanwhile the pattern for SBP seen fluctuate, decline in the amount of 75-1500mg/d sodium intake and then slight increase in the higher amount of sodium intake (Picture 1.c). The fluctuate pattern of SBP and DBP changes according to the score of SRQ can be seen in Picture 1.d. SBP seen the decrease in SRQ score 6-10, but thereafter seen to increase with the increasing SRQ score, in DBP changes also seen a decrease in SRQ score 6-10, and then increase in SRQ score 11-15, and after that sharply decrease in SRQ score 16-20.

Table 1. Characteristic of hypertensive adults and pre-elderly in years 2015

Variable	Hypertensive Adults (N=27)		Hypertensive Pre-Elderly (N=181)		
	n	%	n	%	
Sex					
Male	11	40.7	62	34.3	
Female	16	59.3	119	65.7	
Education Level					
Low (no education-junior high school)	9	33.3	124	68.5	
High (high school-college)	18	66.7	57	31.5	
Employment status					
Unemployment	2	7.4	8	4.4	
Employed	25	92.6	173	95.6	
Nutritional Status					
Lean (<18.5 kg/m2)	0	0.0	3	1.7	
Normal (18.5-25.0 kg/m2)	7	25.9	61	33.7	
Overweight (25.1-27.0 kg/m2)	0	0.0	40	22.1	
Obese (>27.0 kg/m2)	20	74.1	77	42.5	

Cont... **Table 1. Characteristic of hypertensive adults and pre-elderly in years 2015**

Systolic Blood Pressure					
≥ 140 mmHg	13	48.1	136	75.1	
<140 mmHg	14	51.9	45	24.9	
Diastolic Blood Pressure					
≥ 90 mmHg	20	74.1	95	52.5	
<90 mmHg	7	25.9	85	47.5	
Sodium intake					
Normal (≤ 2300 mg/d)	16	59.3	139	76.8	
Excess (> 2300 mg/d	11	40.7	42	23.2	
Mental Health Status					
Stress (SRQ <6)	2	7.4	25	13.8	
Not stress (SRQ ≥6)	25	92.6	156	86.2	

SRQ=self-report questionnaire

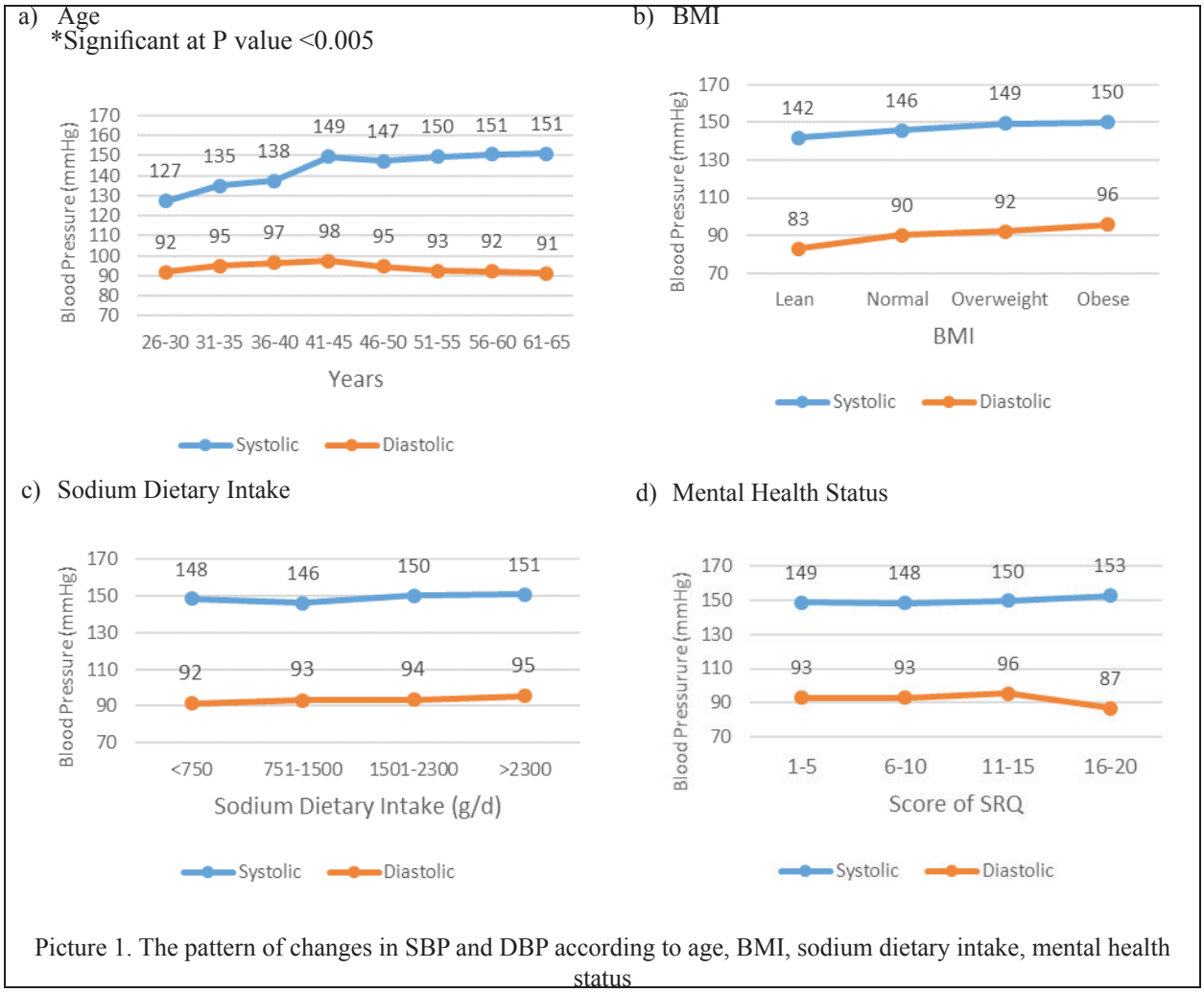
Table 2. Mean of SBP, DBP, BMI, sodium intake, score of SRQ in years 2015-2017

Variable	Year	N	Mean	Min.	Max.	P value
SBP (mmHg)	2015	208	149.39	99.00	237.50	0.416
	2016	208	147.39	94.50	231.50	
	2017	208	148.73	103.50	228.50	
DBP (mmHg)	2015	208	90.98	65.50	121.00	0.0001*
	2016	208	94.54	64.50	134.50	
	2017	208	93.86	70.00	136.50	
BMI (kg/m2)	2015	208	26.91	16.08	40.59	0.316
	2016	208	27.05	15.83	41.59	
	2017	208	26.95	13.97	42.39	
Sodium Intake (mg/d)	2015	208	1831.64	96.00	8354.00	0.0001*
	2016	208	1770.86	190.53	8598.09	
	2017	208	2340.79	206	6843	
Mental health	2015	208	2.54	0	18	0.013*
(A score of SRQ)	2016	208	1.84	0	12	
	2017	208	2.13	0	15	

SBP=Systolic blood pressure; DBP=diastolic blood pressure; BMI=body mass index; SRQ= self-report questionnaire

*Significant at P value <0.005

SE=standard error; Prob.=probability; BMI=body mass index.



Picture 1. The pattern of changes in SBP and DBP according to age, BMI, sodium dietary intake, mental health status

Table 3. Fixed effect model of systolic/diastolic blood pressure with age, nutritional status, sodium intake and stress

	Coefficient	SE	Prob.	Prob. (F-statistic)	Adjusted R2	R2
Systolic blood pressure						
Constanta	113.328	38.43	0.0034*			
Age	-0.646	0.67	0.3335	0.0001*	54,86%	0,70
BMI	2.472	0.60	0.0001*			
Sodium Intake	0.001	0.00	0.0564			
Stress	0.113	0.29	0.6997			
Diastolic blood pressure						
Constanta	-7.589	21.12	0.7195			
Age	1.379	0.37	0.0002*	0.0001*	55,41%	0,71
BMI	1.027	0.33	0.0020*			
Sodium Intake	0.000	0.00	0.4876			
Stress	0.089	0.16	0.5789			

The dynamic of changes in systolic blood pressure and diastolic blood pressure

To quantify the relationship between independent variables and dependent variable we were using regression panel data. Panel data is better suited than cross-sectional data for studying the dynamic of change of blood pressure (SBP and DBP). Based on the result of the Hausman test (SBP: p value = 0.0134; DBP: p value = 0.0009), the best model to describe the changes of SBP and DBP was fixed effect model (FEM).

The result of FEM to describe the dynamic of SBP changes shown in Table 3, it indicated that variable of age, BMI, sodium intake and stress are simultaneous influence to SBP proved statistically significant ($p<0.05$). The magnitude of influence was 54.86%, while the remaining 45,14% was the influence of other factors outside the model, and the ability of the predictor variable is strong in explaining the change of systolic blood pressure (R^2=0,7). Based on the panel data regression equation (**SBP = 113.33 - 0.65 Age + 2.47 BMI + 0.001 Sodium Intake + 0.11 Stress)**, it can be interpreted that if BMI increases by 1 kg/m^2, the systolic blood pressure will increase by 2.47 mmHg after adjusting for age, sodium intake and stress.

Table 3 also presented the dynamic of change of DBP was the simultaneous influence of variable of age, BMI, sodium intake and stress, it proved statistically significant ($p<0.05$). The magnitude of influence was 55.41%, while the remaining 44,59% were influence by other factors outside the model, and the ability of the predictor variable is strong in explaining the change of diastolic blood pressure (R^2=0,7). The panel data regression equation (**DBP = -7.59 + 1.38 Age + 1.03 BMI + 0.00 Sodium Intake + 0.09 Stress)**, can be interpreted that if BMI increases by 1 kg/m^2, the diastolic blood pressure will increase by 1.03 mmHg, after adjusting for age, sodium intake and stress. The regression equation also shown if age increases by 1 year, the diastolic blood pressure will increase by 1.38 mmHg, after adjusting for BMI, sodium intake and stress.

Discussion

Blood pressure is a variable that is always changing in individuals during the follow-up periode[6]. The relationship between blood pressure level and mortality has been investigated in many studies[7,8,9]. Our study confirmed the previous findings for a number of important causal factors for blood pressure changes, namely age[10], BMI[11,12], sodium intake[13] and mental health status/stress[14]. Those factors proved statistically significantly simultaneously influencing the changes of SBP and DBP. Actually, the blood pressure regulation originates from a complicated interaction of genes and several environmental risk factors, including the factors previously mentioned (aging, elevated BMI, elevated sodium intake, and stress)[15].

Some genetically related factors could include inappropriately high activity of the renin-angiotensin-aldosterone system and the sympathetic nervous system as well as susceptibility to the effect of dietary salt on blood pressure can be one of the causes of hypertension[16]. Many studies have documented that dietary salt intake level positively associated with the blood pressure level[17,18]. A high salt intake induces a slight increase in $[Na^+]_p$ and/or $[Na^+]_{csf}$ which, when sensed by the lamina terminalis sodium/osmoreceptor, triggers, in susceptible individuals, the hypothalamus neuromodulatory signaling chain, activating the sympathetic nervous system. An increased activity of the sympathetic nervous system in the kidneys results in increased renin secretion and renal tubular sodium reabsorption and, consequently, in a shift to the right of the pressure natriuresis relationship is due to an increased activity of the renal sympathetic nerves, and ultimately can increase blood pressure[19]. In this study, although the pattern of SBP and DPB mean showed an increase with elevated sodium intake (Picture 1.c), however the increase in blood pressure of sodium intake could not predict statistically with a fixed effects regression model. The magnitude of the relationship between stress and blood pressure also cannot be predicted by the fixed effects regression model.

Blood pressure increases with age[20], this is another common cause of hypertension and mostly related to changes in arterial and arteriolar stiffness[21]. An age-related increase in systolic blood pressure is primarily responsible for an increase in both incidence and prevalence of hypertension[3,20]. Correspondingly, the results of this study indicate that the proportion of hypertensive pre-elderly (87%) were higher than hypertensive adult (13%). Diastolic blood pressure also increases with age but may even fall at late ages[20], in this study, DBP mean shown decrease at the age of 46-50 years (Picture 1.a), the decrease of DBP may cause by the process of large arterial stiffness due to atherosclerotic structural alterations and calcification[22]. The prediction of the increase of DBP by the age shown

in the result of fixed effects regression model that DBP of hypertensive people aged 26-59 years predicted will increase by 1.38mmHg if age increases by 1 year after multivariable adjustment. Meanwhile, the increase of SBP by age could not statistically predicted by fixed effects regression models.

A significant positive correlation between BMI and blood pressure are well documented[23,24]. The mean of SBP and DBP among different BMI categories was evaluated, it was found that mean SBP and DBP increased with increasing BMI from lean category/ lowest BMI to the obese category/highest BMI (Picture 1.b). The potential mechanisms linking increasing BMI to elevated blood pressure include many factors such as dietary factors, endothelial and vascular dysfunction, metabolic, proteinuria, sodium retention, neuroendocrine imbalances, glomerular hyper filtration, and maladaptive immune and inflammatory responses[25].

Our analysis of the magnitude association between BMI and blood pressure is higher than other studies in China and Europe, in this hypertensive population study, a one unit, BMI increase was associated with 2,47mmHg SBP and 1.03mmHg DBP after multivariable adjustment. In China, the association between BMI and BP in subgroup were not taking antihypertensive medication ranging from 0.8 to 1.7mmHg/(kg/m^2), and substantially higher compared with subgroup were taking antihypertensive medication ranging from 0.2 to 0.6 mmHg/(kg/m^2)[12]. In line with the study in China, the study in Europe among the untreated people, a one-unit, BMI increase was associated with 1.27 mmHg SBP after multivariable adjustment[26]. The limitation of our analysis that we could not adjust for the intake of fruit, vegetables, antihypertensive medication, and also other confounders that might have implications for blood pressure changes, which those factors might have some effects on our results.

Conclusions

The uncontrolled hypertension can cause very expensive health care burden. The annual global direct health care costs attributable to uncontrolled blood pressure were estimated at US $372 billion, representing about 10% of the world's overall health care expenditures[27], and improved blood pressure control at population level could have a positive impact in decreasing morbidity and mortality[28]. For Indonesian, our analysis suggests for including the information about the BMI changes in the hypertension monitoring reports, as indicators of early awareness of risk factors and prognostic factors for increased blood pressure.

Conflict of Interest Statement: There are no conflict of interest.

Ethical Clearance: This research has received ethical approval from "The Research and community engagement Ethical Committee Faculty of Public Health Universitas Indonesia", Ket- 432/UN2.F10/ PPM.00.02/2019.

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