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AGE, BODY WEIGHT, BODY MASS INDEX, AND SLEEP DURATION IN PREDICTING HYPERTENSION INCIDENCE AT PRODUCTIVE AGE IN MEDAN CITY

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Abstract

Hypertension defines as elevated blood pressure with systolic blood pressure above 140mmHg and/or diastolic blood pressure above 90mmHg. Hypertension affects 1,13 billion worldwide, mainly in low and middle-income countries. Generally, the classification of hypertension is divided into optimal, normal, high normal, grade 1, grade 2, and grade 3. Age, body weight, body mass index, and sleep duration can increase the risk of hypertension incidence. This study aimed to determine the cut off value of each variable to predict the hypertension incidence in Medan city. 352 respondents assessed with subjective questionnaire, blood pressure measurement, body weight, height and analyzed with Mann Whitney, ROC curve, and last Chi-Square with Yates correction. All variables were significantly associated (p-value<0,001) with hypertension incidence with cut off values: 45 years old, lower than 5,5 hours per night, greater than 65 kg for the body weight, and greater than 25 kg/m^2. Age, body weight, body mass index, and sleep duration were associated and can be a good predictor for hypertension incidence.

Keywords : ***Age, body weight; body mass index; sleep duration; hypertension***

INTRODUCTION

Hypertension defines as elevated blood pressure, that can be diagnosed when systolic blood pressure is above 140 mmHg and/ or diastolic blood pressure above 90 mmHg.[1] In 2015, 1,13 billion people had hypertension, largely in low and middle-income countries.[2] According to Indonesia Basic Health Research 2018, the highest incidence was in South Kalimantan, and the lowest was in Papua, 44,1% and 22,2%, respectively. The incidence of hypertension in North Sumatra is 29.19%.[3] Most hypertension is idiopathic or as known as essential hypertension, which can be caused by various risk factors such as: genetic, age, salt intake, unhealthy diet, alcohol usage, smoking, inactive physical activity, obesity, lack of sleep, and longstanding stress.[4,5] Hypertension according to European Society of Cardiology, can be classified into: optimal (<120/<80 mmHg), normal (120-129/ 80-84 mmHg), High normal (130-139/ 85- 89 mmHg), grade 1 (140- 159/ 90- 99 mmHg), grade 2 (160-

179/ 100- 109 mmHg), grade 3 (≥180/ ≥110 mmHg) and isolated hypertension (≥140/ <90 mmHg).[6] According to American Heart Association, normal blood pressure defines as systolic <120 mmHg, diastolic 80 mmHg, elevated normal 120-129/ <80 mmHg, stage 1 hypertension 130- 139/ 80- 89 mmHg, and grade 2 ≥140/90 mmHg.[7] In addition, Indonesia's Society of Hypertension divided hypertension to: optimal (<120/<80 mmHg), normal (120-129/80-84 mmHg), high normal (130-139/85-89 mmHg), grade 1 (140-159/90-99 mmHg), grade 2 (160-179/100-109 mmHg), grade 3 (≥180/ ≥ 110 mmHg), and isolated systolic hypertension (≥140/ <90 mmHg).[8]

Body mass index (BMI) is a tool for gross body fat measurement, where dividing body weight in kilograms with body height in meter square, and expressed in kg/m^2.[9] There are differences in body mass classification. According to World Health Organization (WHO), BMI <18,5 kg/m^2 is classified into underweight, 18,5- 24,9 kg/m^2 normal, 25-29,9 kg/m^2 overweight, and obese ≥30 kg/m^2; on the other hand, in the Asia Pacific, normal defines BMI < 18,5, normal 18,5- 22,9 kg/m^2, overweight 23- 24,9 kg/m^2, and obese ≥25 kg/m^2.[10]

First, blood pressure is associated with the ageing process. Ageing causes chronic, low-grade inflammation and increased cellular oxidative stress, inflammatory can induce production of the cytokines, Reactive oxygen species (ROS), and lead to hypertension.[11] Hypertension can be caused by arterial stiffing, which started from the ageing process, and an increase in metabolic syndrome prevalence, neurohormonal disorders, increase the inflammatory process. Body fat is associated with arterial stiffening that can cause metabolic syndrome induces arterial stiffing.[12]

Body mass index has a strong relationship with blood pressure too, where higher BMI has a role in inflammatory processes, which fat cells induce lipolysis and producing high quantities inflammatory cytokines, finally affect the blood pressure and organ damage. However, it is still unclear about the exact mechanism.[13] Another study claimed that overweight could cause renal vasodilatation and glomerular hyperfiltration, which resulted in increased sodium reabsorption, increased arterial blood pressure, and other inflammatory factors such as oxidative stress, hormones, and nitric oxide.[14] A previous study showed that age was positively associated with both systolic and diastolic blood pressure. This study stated that the age factor was a more significant factor than the body mass because of modernization that changes the lifestyle factors nowadays.[15]

Next, lack of sleep is also associated with higher blood pressure; sleep consists of 4 stages, rapid eye movement (REM) and non-rapid eye movement (NREM); the first step is the wake step, NREM stage 1, NREM stage 2, NREM stage 3, and lastly the REM sleep where the skeletal muscles are atonic, breathing rate is altered.[16] Short sleep duration is defined as a duration of fewer than 7 hours

per night. It is associated with elevated blood pressure by activation of the sympathetic system, stimulation of the renin-angiotensin-aldosterone system, and an increase in central catecholamine, which leads to vasoconstriction of the blood vessel and hypertension.[17] Another study stated that sleep disturbance affects blood pressure (p-value <0,001), lack of sleep will affect the stress level, hypothalamic pituitary adrenal (HPA) axis and promote wakefulness and increase blood pressure, adrenocorticotropic hormone (ACTH) and cortisol levels are secreted higher too in an individual with short sleep duration.[18]

The aim of this study was to determine the cut-off point and also the best predictor of age, body mass index, and sleep duration to predict hypertension incidence at productive age in Medan city, where North Sumatra (Medan city) has the highest hypertension incidence in Sumatera island.

METHOD

This study was conducted in Medan city between August 6 to August 13, 2014, a cross-sectional investigation and non-random consecutive sampling method. The inclusion criteria of this study were all workers in Medan city who came to the workplace clinic, 18 to 60 years of age, and exclusions criteria were subjects who refuse to join in this study, diagnosed with secondary hypertension before. A total, 63 subjects were the minimum sample for each group, 126 subjects for two groups. This study was part of the bachelor of medicine thesis in the Faculty of Medicine Tarumanagara University. It began with proposal drafting with the supervisor, ethical clearance from the institution, and the study places. This study had received four permit letters for the institution Faculty of Medicine Tarumanagara University: No.060/UU/VIII/14; No.015/VIII/2014; No.013/VIII/2014; and No.027/SCA/VIII/14.

Body mass index with body weight and height measurement with validated measure tape and scale, one-month sleep duration average in the questionnaire were the independent variables. By contrast, Blood pressure measurement with a validated sphygmomanometer, twice in the seated position, 15 minutes gap between each measurement and divided into two classifications (with or without hypertension). This study used an independent t-test or Mann Whitney, Receiver operating characteristic (ROC) curve to determine the cut- off point in BMI and sleep duration. A normality test was performed before with Kolmogorov- Smirnov and Shapiro Wilk and Levene Test for the variance between groups.

Analysis of this study used an independent t-test for normal data and Mann Whitney as the alternative test for abnormal data. If the p-value< 0,05, then the variables would be tested again with the ROC to predict the cut off value each variable. The value of ROC or Area Under Curve (AUC) has a good predictor ability if the deviation angle above 45 degrees and p-value <0,05. The AUC value test will be divided into 5 groups: AUC 0,90 – 1,00 as excellent, 0,80 – 0,90 as good, 0,70 –

0,80 as fair, 0,60 – 0,70 as poor and 0,50 – 0,60 failed the test. If the AUC value below 0,50, the conversion AUC method will be used with the formula (1- Base AUC) and variable accuracy strength as the predictor parameter. After the determination of the ROC curve, then the cut-off point for the variables was determined. Furthermore, from the cut-off point, sensitivity, specificity, negative predictor value, and positive predictive value for each independent variable were sought in estimating the dependent variable. Finally, using Chi-Square with Yates Connection to each the p-value and prevalence risk between the independent and dependent variables.

RESULTS

A total of 352 respondents were participating in this study, consists of 113 men and 239 women, with the average age of 41,13 (9,93) years old. The most occupation among all was a general employee, 305 (86,6%) respondents, and the least was government employee 1 (0,3%) respondents. Java race was the highest percentage among the other race, with 138 (39,2%) respondents, followed by Batak 96 (27,3%) respondents. The Mean of Systolic Blood pressure, diastolic blood pressure, body weight, body height and body mass index were 127,7 (18,74) mmHg, 86,45 (10,44) mmHg, 62,48 (12,42) kg, 158,23 (8,41) cm, and 24,95 (4,62) kg/m^2, respectively. Most of them did have hypertension history in the family, with 182 (51,7%) respondents, no alcohol consumption history, 322 (91,5%) respondents. On average, 6,18 (1,73) hours was the average sleep duration, and the majority of the respondents were at optimal blood pressure classification 106 (30,1%) respondents. (Table 1)

Table 1. Base Respondents Characteristics

Parameter	N (%)	Mean (SD)	Med (Min-Max)
Sex			
· Male	113 (32,1%)		
· Female	239 (67,9%)		
Age		41,13 (9,93)	44 (20 - 56)
Occupation			
· Student	23 (6,5%)		
· General Employee	305 (86,6%)		
· Government Employee	1 (0,3%)		
· Manufacturer	5 (1,4%)		
· Businessman	3 (0,9%)		
· Service Entrepreneur	9 (2,6%)		
· Accountant	6 (1,7%)		
Race			
· Java	138 (39,2%)		
· Sundanese	17 (4,8%)		
· Indonesian Chinese	37 (10,5%)		

· Malay	37 (10,5%)		
· Madura	5 (1,4%)		
· Batak	96 (27,3%)		
· Minangkabau	7 (2%)		
· Betawi	4 (1,1%)		
· Indonesian Arabic	1 (0,3%)		
· Banjar	1 (0,3%)		
· Bali	1 (0,3%)		
· Makassar Cirebon	1 (0,3%)		
· Other	6 (1,7%)		
Systolic Blood Pressure		127,7 (18,74)	125 (90 - 180)
Diastolic Blood Pressure		86,45 (10,44)	90 (60 - 115)
Body Weight		62,48 (12,42)	62 (38 - 100)
Body Height		158,23 (8,41)	158 (132 - 190)
Body Mass Index		24,95 (4,62)	24,63 (16,38 - 40,37)
Hypertension Status			
· Yes	118 (33,5%)		
· None	234 (66,5%)		
Family history of hypertension			
· Yes	182 (51,7%)		
· None	170 (48,3%)		
Smoking history			
· Used to or still	73 (20,7%)		
· None	279 (79,3%)		
Alcohol consumption history			
· Yes	30 (8,5%)		
· None	322 (91,5%)		
Sleep Duration		6,18 (1,73)	6 (1 - 12)
· 1 hour	3 (0,9%)		
· 2 hours	14 (4%)		
· 3 hours	16 (4,5%)		
· 4 hours	28 (8%)		
· 5 hours	26 (7,4%)		
· 6 hours	91 (25,9%)		
· 7 hours	97 (27,6%)		
· 8 hours	68 (19,3%)		
· 9 hours	6 (1,7%)		
· 10 hours	2 (0,6%)		
· 12 hours	1 (0,3%)		
Blood Pressure Classification			
· Optimal	106 (30,1%)		
· Normal	80 (22,7%)		
· High Normal	46 (13,1%)		

·	HT grade 1	89 (25,3%)
·	HT grade 2	28 (8%)
·	HT grade 3	3 (0,9%)

From table 2, the average age of respondents without hypertension was 38,78 (10,8) years old, in contrast with hypertension was 45,8 (5,51) years old. Respondents without hypertension on average sleep for 6,55 (1,45) hours, and 5,46 (2) hours for hypertension. 59,67 (11,75) kg was the average body weight for normal blood pressure, 68,07 (11,84) kg was for the hypertension, and BMI of 24,11 (4,38) kg/m^2 for normal group and 26,63 (4,63) kg/m^2 for the hypertension. (Table 2 and Figure 1-4)

Tabel 2. Blood Pressure Mean Differences of Age, Sleep Duration, Body Weight, Body Mass Index to Hypertension Incidence

Parameter	Blood Pressure										*p-value*
	Normal (N: 377)					Hypertension (N: 547)					
	Mean	SD	Med	Min	Max	Mean	SD	Med	Min	Max	
Age	38,78	10,80	42	20	56	45,80	5,51	47	22	56	<0,001
Sleep Duration	6,55	1,45	7	1	12	5,46	2,00	6	1	9	<0,001
Body Weight	59,67	11,75	58	38	100	68,07	11,84	70	43	95	<0,001
BMI	24,11	4,38	23,76	16,38	40,37	26,63	4,63	27,49	17,44	39,8	<0,001

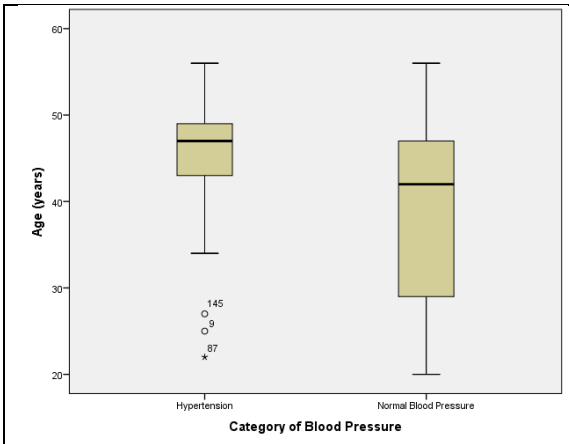


Figure 1. Mean Difference of Age to Hypertension Incidence

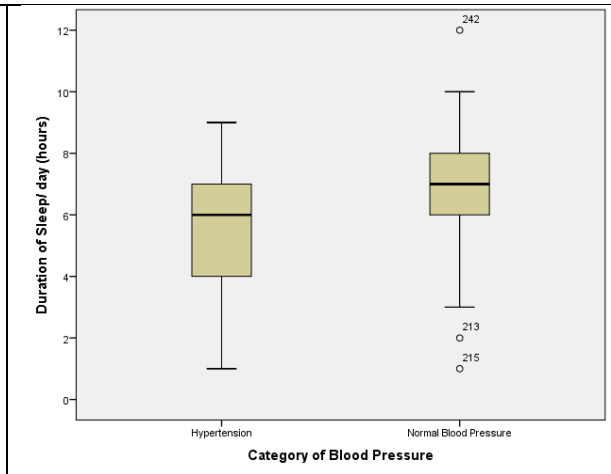


Figure 2. Mean Difference of Sleep Duration to Hypertension Incidence

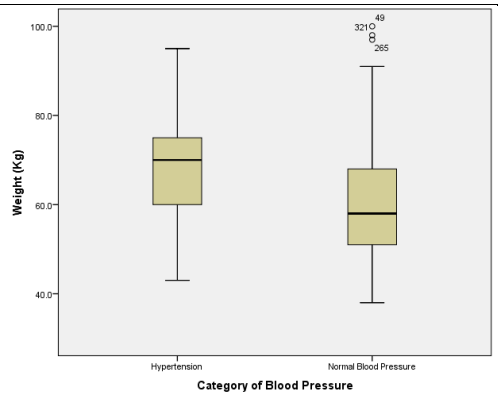


Figure 3. Mean Difference of Body Weight to Hypertension Incidence

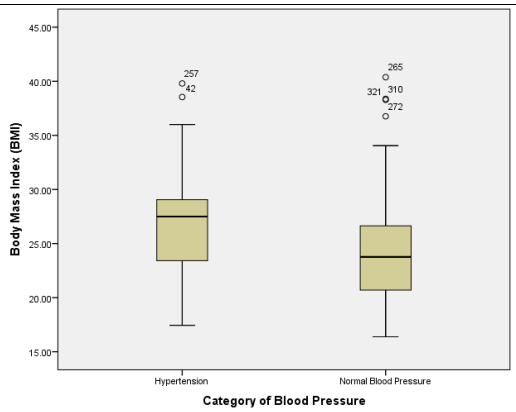


Figure 4. Mean Difference of body mass index to Hypertension Incidence

From the statistical result between mean differences between 2 groups, 4 variables could be tested to predict the incidence of hypertension with age, sleep duration, body weight, and body mass index. Next, the ROC curve will be used for these four variables to test how strong each variable to predict hypertension incidence. AUC for age, weight, body mass index, and duration of sleep were 0,694, 0,7, 0,66, 0,64 respectively and p-value 0,000 for all of them. (Figure 5, 6, 7, 8 and Table 3)

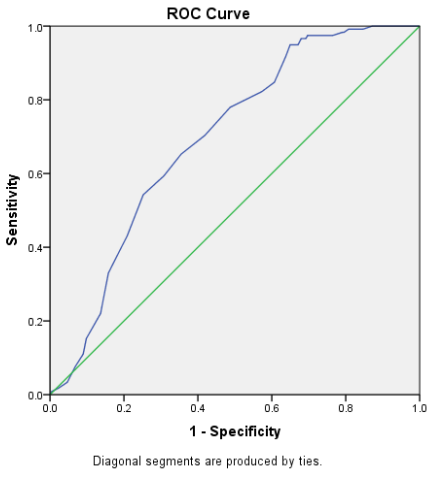


Figure 5. Predictor Parameter ROC curve of Age to Hypertension Incidence

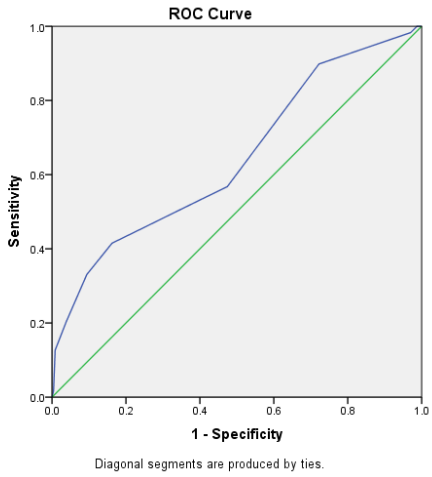


Figure 6. Predictor Parameter ROC curve of Sleep Duration to Hypertension Incidence

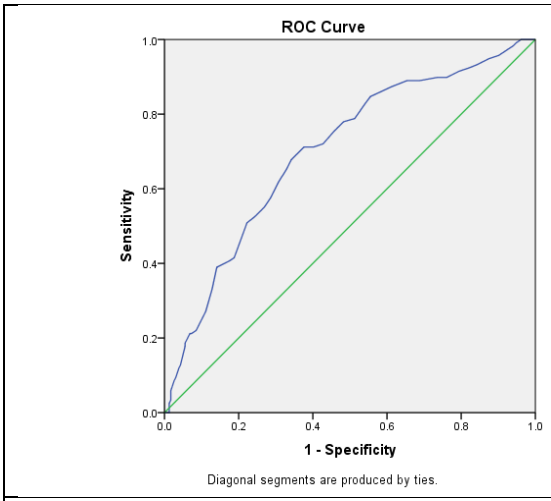


Figure 7. Predictor Parameter ROC curve of Body Weight to Hypertension Incidence

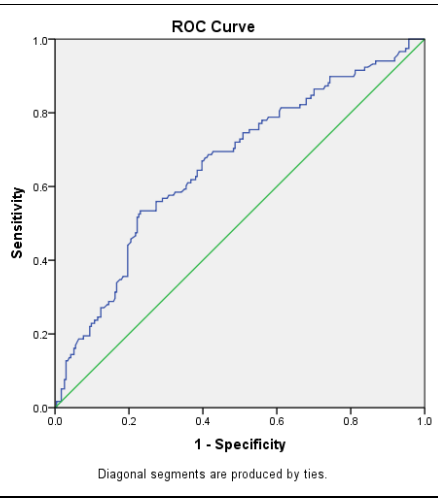


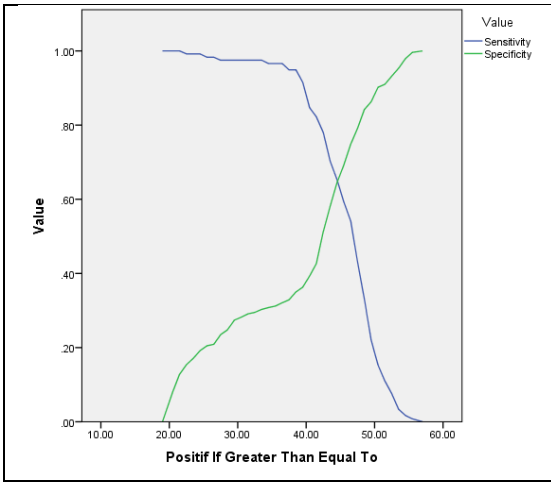
Figure 8. Predictor Parameter ROC curve of Body Mass Index to Hypertension Incidence

Tabel 3. Area Under Curve (AUC) Parameter of Age, Body Weight, Sleep Duration, Body Mass Index as Predictor of Hypertension Incidence

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Age (years)	0.694	0.028	0.000	0.640	0.749
Body Weight (Kg)	0.700	0.029	0.000	0.643	0.758
Body Mass Index (BMI)	0.662	0.031	0.000	0.601	0.723
Sleep Duration	0.644	0.032	0.000	0.581	0.706

The test result variable(s): Age, Weight, Body Mass Index, Sleep Duration, has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

Next, from the ROC curve each variable, we determine each cut-off value which can increase hypertension incidence, the cut-off for the age is more than or equal 45 years old, lower than or equal 5,5 hours per night, greater than or equal 65 kg for the body weight, and greater than or equal 25 kg/m^2 for body mass index. (Figure 9,10, 11, 12)



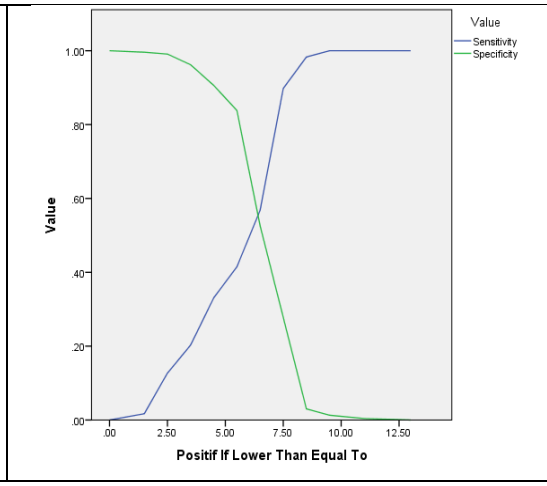


Figure 9. Age Sensitivity and Specificity Cut Off in Predicting Hypertension Incidence

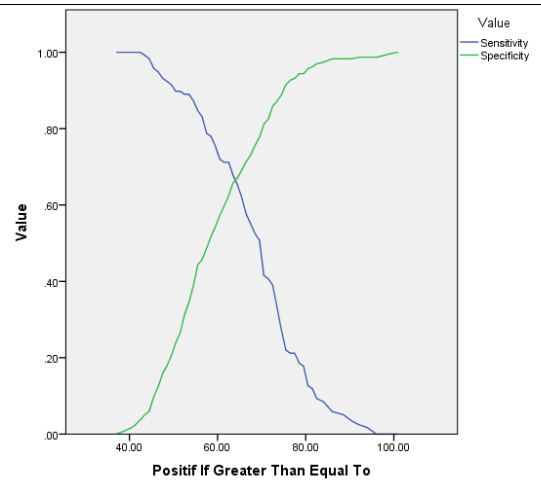


Figure 10. Sleep Duration Sensitivity and Specificity Cut Off in Predicting Hypertension Incidence

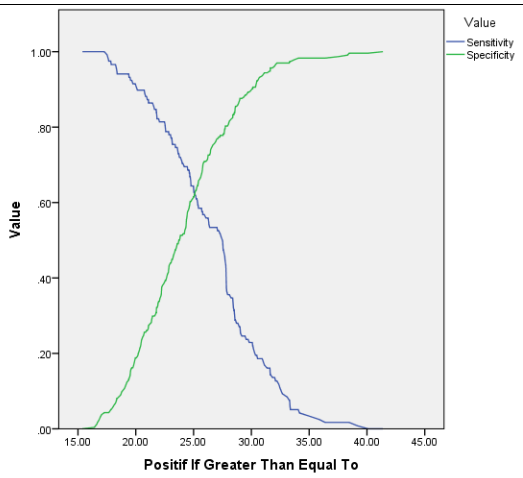


Figure 11. Body Weight Sensitivity and Specificity Cut Off in Predicting Hypertension Incidence

Figure 12. Body Mass Index Sensitivity and Specificity Cut Off in Predicting Hypertension Incidence

The next step is to test the sensitivity and specificity each variable, first the sleep duration below or equal 5,5 hours, the sensitivity is 41,52%, specificity 83,76%, positive predictive value 41,88%, and negative predictive value 73,96% to hypertension incidence, second, the minimum age 45 years old, the sensitivity 65,25%, specificity 64,52%, positive predictive value 62,5%, negative predictive value 78,64%. Third, the bodyweight variables greater than or equal 65 kg, the sensitivity 65,25%, specificity 66,22%, positive predictive value 50%, and negative predictive value 78,64%. Last is the body mass index greater than or equal 25 kg/m^2, the sensitivity 64,41%, specificity 61,54%, positive predictive value 45,78%, and negative predictive value 77,42%.

The last statistic test used was Pearson Chi-Square with Yates Correction to determine the association between each variable to the hypertension incidence. According to the Pearson Chi-Square with yates Correction, all the variables had a significant association, first the sleep duration less than 5,5 hours with p-value <0,001 and 2,16 prevalence risk to hypertension incidence, age greater than 45 years old with p-value <0,001, and had 3,09 times risk to hypertension incidence, body weight more than 65 kg with p-value <0,001 and 3,3 prevalence risk and lasted the body mass index more than 25 kg/m^2 p- value< 0,001 and 2,69 prevalence risk. (Table 4)

Table 4. Association of Sleep Duration, Age, Body Weight, Body Mass Index to Hypertension Incidence

Parameter		Hypertension		Normal		PR	CI 95%		*p*
		N	%	N	%		Min	Max	
Sleep Duration	≤ 5,5 hours	49	56,3	38	43,7	2,163	1,644	2,847	<0,001
	> 5,5 hours	69	26	196	74				
Age	≥ 45 years old	77	48,1	83	51,9	2,254	1,644	3,09	<0,001
	< 45 years old	41	21,2	151	78,6				
Body Weight	≥ 65 kg	77	50	77	50	2,415	1,762	3,309	<0,001
	< 65 kg	41	20,7	151	79,3				
BMI	≥ 25 kg/m^2	76	45,8	90	54,2	2,028	1,482	2,774	<0,001
	< 25 kg/m^2	42	22,6	144	73,4				

DISCUSSION

According to the previous study, on average systolic blood pressure rises to age 50 and the declines, except in untreated hypertension, where it declined in period>85 years. On the other hand, systolic blood pressure changed little concerning aging.[19] The further study concludes that age over 50 years old had 1,56 times more likely to have hypertension and over 70 years had almost two times. It may cause by arterial thickening as it gets more aged.[20] The results of this study are similar to the one we conduct, where the cut off value for predicting hypertension incidence is 45 years old. The incidence rate of hypertension in Portugal, below 40 years old was 23,1(women), 40(men) per 1000 person-years, increases to 53,1(women), 62(men) in age 40 to 60 years, and 110(women), 64,4(men) for above 60 years old with the p-value 0,032.[21] Additionally, another study stated that the prevalence of hypertension for adults (above 45 years old) was 74,3% for men and 70,2% for women, and increases like 7,3% for 18 to 39 years old to 66,3% for age over 60 years old.[22]

Increase of blood pressure caused by an increase of body mass index, by 0,3 kg/m^2 and 2,4 kg/m^2 for normotensive and hypertensive patients, respectively, visceral fats can trigger insulin resistance and renin–angiotensin–aldosterone system (RAAS), sodium reabsorption, which ends to increase of blood pressure, in contrast lowering the BMI can reduce the systolic blood pressure by 23 mmHg, and 9mmHg of diastolic blood pressure (p- value=0,005).[23-25] In India, the study about the ROC curve of BMI and hypertension found that BMI is a good predictor variable for hypertension incidence with the cut off value BMI ≥24,5 kg/m^2 for men, and ≥24,9 kg/m^2 for women, with the area under the curve 0,714 (men), 0,821 (women). Hence, adults who have a higher BMI had a higher risk of having hypertension (p-value<0,001).[26] This study has a similar conclusion as the survey we conduct in which the cut-off value for BMI is 25 kg/m^2. Next, another study concluded BMI could be a useful predictor of hypertension in adults, the cut- off values were over 23 kg/m^2 for men and over 20 kg/m^2 for women; for addition, another research results conclude the same things also, the optimal cut off values for predicting the hypertension incidence was 23,53 kg/m^2 with 55,5% sensitivity and 67,6% specificity.[27,28] However, one study suggested that waist circumference is a more reliable predictor than

BMI for hypertension incidence. In that study, the BMI cut off values was 25,45 kg/m^2, because abdominal fat has more effect on blood pressure than BMI alone, the combination of BMI and waist circumference can better predict the risk of hypertension.[29] Moreover, the cut off values for BMI for predicting hypertension in China's research were 24,39 kg/m^2 with sensitivity 63,75% specificity 60,2% for men, 23,95 kg/m^2 with sensitivity 63,3% and specificity 64,1% for women, while these cut off had the best prediction of hypertension and diabetes, while still the best predictor is using waist to height ratio.[30] In our study, we only search the cut off value of BMI, neither waist circumference nor waist to height ratio.

Finally, shorter sleep duration is associated with an increase in hypertension incidence. One study found that objective sleep duration that less than 6 hours is associated with a rise in hypertension prevalence, with 3,59 times increased risk of hypertension. It was caused by shorter sleep duration makes higher psychological hyperarousal, resulted in more vulnerable to medical comorbidities.[31] However, this study used an objective sleep duration with Polysomnography, different from our research which only used a subjective based questionnaire, but with the same cut off values of less than 6 hours of sleep duration. Longer sleep duration also gives a better benefit for cardiometabolic health. In one study, a good sleep cut off is defined as 5 hours 20 minutes to 7 hours of sleep, associated with the risk of cardiometabolic morbidity (p-value= 0,044).[32] Younger adults (less than 65 years old) who slept <5 hours per day had 1,5 more times risk for hypertension than those who slept for 7 hours. In contrast, adults over 65 years, there is no association between sleep duration and hypertension risk, similar to those who slept more than 8 hours, no association found either.[33]

CONCLUSION

Age, Bodyweight, Body mass index, and sleep duration were associated with hypertension incidence (p-value<0,001) and it can increase the risk of hypertension; thus, we recommend the cut-off values of age was more than 45 years old, body weight greater than 65 kg, lower than 5,5 hours per night sleep duration, and BMI greater than 25 kg/m^2 that can increase the risk of hypertension incidence. Larger study group and newer study is suggested for next research.

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