ORIGINAL ARTICLE

Factors associated with hypertension among the elderly in Kudat, Malaysia

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ABSTRACT

Introduction: Hypertension among the elderly population aged 60 years and above in Malaysia was estimated to be around 69.2%. The high association of hypertension with morbidity and mortality among older communities warranted targeted public health interventions. Hence, this study aimed to determine the prevalence of hypertension and its related factors among the elderly in a rural area in Kudat, Sabah.

Materials and Methods: This cross-sectional study was carried out to determine the prevalence of hypertension, including previously known and newly diagnosed cases, and the associated factors among the elderly aged 60 and older living in the rural part of Sabah. The study was conducted on 700 elderly people living in Kudat using self-administered and interviewer-assisted JAGES questionnaires and physical status measurements from January to March 2023. Multivariate logistic regression analysis was applied to determine the association between sociodemographic and physical factors with hypertension among the elderly.

Results: The prevalence of hypertension among elderly dwelling in Kudat, Sabah was approximately 80.3% (95% CI: 77.35, 83.25), slightly higher than the national prevalence. The findings also indicated that older age group (aOR=3.2; 95% CI: 1.548, 6.489), higher BMI (aOR=1.9; 95% CI: 1.170, 2.997) abnormal waist circumference (aOR=2.5; 95% CI: 1.573, 4.022), and active smoking (aOR=2.4; 95% CI: 1.281, 4.626) were significantly associated with hypertension among the elderly community.

Conclusion Focused and targeted prevention, intervention, and management of hypertension for the elderly, especially those dwelling in rural areas, should be constructed to tackle the issue of high prevalence of hypertension among them, thus reducing morbidity and mortality related to elderly hypertension towards healthy ageing.

KEYWORDS:
elderly, hypertension, factors associated with hypertension, community, rural

INTRODUCTION

The ageing population is a global phenomenon. Advancing life expectancy, improved mortality outcomes, and declining fertility and population growth rates have changed the population's age structure over time.[1] People, especially in developed countries, are living longer and healthier with the amelioration of healthcare delivery worldwide. In 2020, about 727 million people were aged 65 years or over. This share of the world population is expected to increase from 9.3% to 16% in 30 years. This figure already outnumbered children aged less than five years old in 2020.[2]

Many chronic illnesses remain the leading causes of mortality and morbidity among the elderly, therefore instantly impacting their quality of life.[3] Hypertension, while not particularly a degenerative disease, is constantly increasing worldwide. It is a common and significant health issue among the elderly population, affecting around 67% of adults aged 60 and older in the United States [4] and 57% of older adults aged more than 50 years in African regions.[5] Shanghai, China, where a large population of elderly residents resided, also had a high prevalence of hypertension, estimated at around 59.9% among the elderly aged 65 years and older.[6] A similar finding was reflected in Malaysia's National Health and Morbidity Survey 2019. The prevalence of overall high blood pressure increased with age, from 5.7% among those aged 20 to 24 to 81.7% among those aged 75 and older, the highest of any age group in the report.[7] The prevalence was also notably higher in rural areas, at 32.8%, than in urban areas, at 29.2%. Health issues in Malaysian rural regions vary but may not be as well-addressed as in urban areas due to restricted access to healthcare services.[8]

Multiple risk factors for hypertension, including obesity, excessive sodium intake, alcohol consumption, and lack of physical activity, have long been identified and described.[9] Declining handgrip strength has also been consistently linked to an increased risk of hypertension, as evidenced by multiple large-scale studies, including NHANES in the US and KNHANES in South Korea.[10,11] The underlying mechanism may involve age-related muscular degeneration, systemic inflammation, hormonal changes and reduced physical activity, contributing to cardiovascular and metabolic

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vulnerability.[12] Similarly, betel chewing has been identified as a behavioural risk factor for elevated blood pressure.[13] The effect is thought to be mediated through systemic inflammation and stimulation of the renin-angiotensin system, mechanisms comparable to the hypertensive effects of alcohol.

In this study, we focused on determining the association of social, economic, and physical status with hypertension among the elderly. This study is structured to gain knowledge that may tackle the issues, emphasising prevalence and sociodemographic factors (age, sex, ethnic, religion and marital status), socioeconomic factors (education, income, employment), physical status (BMI, waist circumference, handgrip strength), social behaviours (smoking, alcohol, betel chewing), and depression status as modifiable risk factors that can be improved among hypertensive elderly in rural Sabah.

MATERIALS AND METHODS

Research Design and Subjects

This cross-sectional study was conducted in northern Sabah, Kudat, as part of a larger longitudinal survey, "Healthy Ageing in Sabah." The study enrolled participants aged 60 or older who lived in the rural area of Kudat, Sabah. Elderly individuals who were bedridden and cognitively impaired were excluded from the study. Data were collected by trained personnel either by an interviewer-assisted method or self-administered questionnaires.

Instruments Used

The study tool included a self-administered and interviewer-assisted questionnaire, which comprised two main components: social epidemiological questions and general health status, as measured by physical and mental attributes. The social determinants of health and functional status include demographic aspects such as age, sex, ethnicity, income status, employment status, educational level, marital status, lifestyle aspects (tobacco smoking, alcohol drinking and betel chewing) and morbidity (hypertension status).

A validated 15-item Geriatric Depression Scale (GDS-15) in Bahasa Malaysia was used to assess depressive symptoms among the target population. This instrument has been locally validated and demonstrates excellent internal consistency (Cronbach's $\alpha = 0.89$).[14] A score of four or less indicated no depressive symptoms, 5 to 8 for mild, 9 to 11 for moderate, and 12 to 15 for severe depression.

The blood pressure measurement was recorded using an automatic BP machine by Omron (Omron Digital Automatic Blood Pressure Monitor Model HEM-8712). The measurement was set with an appropriately sized cuff bladder (encircling at least 80% of the arm). Two blood pressure readings were taken within a minute of one another, and if there was more than a 10 mmHg difference between the first two, a third reading was taken. The final reading was then determined mathematically by calculating the mean blood pressure reading. Those with abnormal blood pressure were examined again on the next day, and if the systolic or diastolic pressure was 140mm/Hg or higher, and a diastolic pressure of 90mm/Hg or higher was deemed to be hypertensive using Malaysia's Clinical Practice Guidelines on Hypertension 2018. Hypertension in this study was defined to include those with known and unknown hypertension, with or without treatment. A referral letter was given for appointments for proper follow-up if blood pressure was raised.

BMI was then calculated using the measured values of height and weight. Overweight was defined as having BMI of 23.0 kg/m2 or more, while obese as 27.5 kg/m2 or more. Those having BMI of less than 23.0 kg/m2 were considered normal according to Malaysia's Clinical Practice Guidelines on Obesity 2023.

Waist circumference was assessed using a measuring tape, with results of 90 cm or above in males and 80cm or above in females considered abnormal.

Lastly, handgrip strength was employed as a proxy indicator for muscle strength. Measurement was carried out using Takei digital Dynamometer TKK 5001 Grip. A grip strength value of less than 28 kg for males and 18 kg for females was used as a cut-off point for poor strength.

The study also employed the Abbreviated Mental Test (AMT) to screen participants for cognitive function before inclusion. The AMT-10 is a validated and widely used tool to assess cognitive impairment. It consists of ten questions that evaluate orientation, memory, and attention. Participants were required to achieve a score of 7 or higher to ensure sufficient cognitive capacity for understanding and responding accurately to the study instruments.

Ethical Consideration

This study received ethical approval from the Research and Ethics Committee of Universiti Malaysia Sabah (UMS) (Approval Code: JKEtika 2/23 [7]). Informed written consent was obtained from the study participants before filling in the questionnaire, and any inquiries from the participants were answered before signing the consent form. Confidentiality of all the information acquired from the study participants was ensured, and the data was used for the intended purpose only. Any participants who were newly diagnosed with hypertension (blood pressure more than 140/90mmHg) and had the abnormal status of depression (mild, moderate, severe) during the survey were given referral letters for further follow-up with the nearest health clinic.

Statistical Analysis

The data collected were recorded into tables in Microsoft Excel 2019 before being analysed using IBM SPSS Version 28.0. Descriptive statistics were used to describe the sociodemographic, socioeconomic, physical status, social behaviours, and depression characteristics of all the participants. The prevalence of hypertension was calculated with a 95% confidence interval. Simple logistic regression was used in univariable analysis to determine the association between independent variables and the presence of Hypertension. The alpha value was set at 0.05 to reject the null hypothesis and determine statistically significant hypertension factors.[15] For bivariate analysis, multiple regression was applied involving all variables with a p-value

Table I: Characteristics of Participants (n = 700)

Characteristics	Frequency, n	Percentage, %
Age (years old)		
60 – 69	385	55.0
70 – 79	236	33.7
>80	79	11.3
Sex		
Male	333	47.6
Female	367	52.4
Religion		
Islam	139	19.9
Christian	552	78.9
Others	9	1.3
Ethnicity		
Rungus	553	79.0
Others	147	21.0
Marital Status		
Married	522	74.6
Unmarried	178	25.4
Education Level		
Primary and Lower	607	86.7
Secondary and Higher	93	13.3
Employment Status		
Employed	279	39.9
Unemployed	421	60.1
Household Income Level (RM)		
0 – 999	526	75.1
>1000	174	24.9
Body Mass Index (BMI)		
Normal	287	41.0
Overweight	413	59.0
Waist Circumference		
Normal	264	37.7
Abnormal	436	62.3
Handgrip Strength		
Poor	286	40.9
Normal	414	59.1
Smoking Status		
Active Smoker	105	15
Ex-smoker	130	18.6
Never Smoke	465	66.4
Alcohol Status		
Active Drinker	114	16.3
Ex-drinker	274	39.1
Never Drink	312	44.6
Betel Chewing Status		
Active Chewer	240	34.3
Ex-chewer	55	7.9
Never Chew	405	57.9
Depression Status		
No	28	4.0
Mild	480	68.6
Moderate	154	22.0
Severe	38	5.4

of less than 0.25.[16] They were analysed using backward and forward methods in SPSS to get the preliminary model of predictors for hypertension.

RESULTS

700 elderly people in rural villages participated in the study. Table I summarises the participants' sociodemographic, socioeconomic, physical, and behavioural characteristics.

We found that 562 participants (80.3%), approximately four in every five elderly, had hypertension with a 95% CI (77.35, 83.25). Based on the descriptive analysis, the majority of people having hypertension were in 60-69 age group (51.6%), female sex (52.7%), Christian religion (79.0%), Rungus ethnic (79.2%), married (72.8%), having total household income less than RM999 (75.3%), attended primary school or lower education (87.4%), unemployed currently (63.0%), having abnormal waist circumference (67.1%), having overweight BMI (63.2%), standard handgrip power (58.5%), never smoked (65.1%), never drank alcohol (45.4%), never chewed betel products (57.1%) and having mild depression status (67.1%) compared to the other categories in the same variables.

Table II: Simple logistic regression of sociodemographic, socioeconomic, physical status and behavioural factors associated with hypertension among the elderly in Kudat, Sabah (n=700)

Variables	Hypertension, n (%)	Crude OR (95% CI)	p-value
Age (years old)			
60 – 69	290 (51.6)	ref	
70 – 79	204 (36.3)	2.088 (1.347, 3.239)	*0.001
>80	68 (12.1)	2.025 (1.028, 3.988)	*0.041
Sex			
Female	296 (52.7)	ref	
Male	266 (47.3)	0.952 (0.656, 1.382)	0.797
Religion			
Islam	112 (19.9)	ref	
Christian	444 (79.0)	0.991 (0.619, 1.586)	0.970
Others	6 (1.1)	0.482 (0.113, 2.052)	0.323
Ethnicity			
Others	117 (20.8)	ref	0.812
Rungus	445 (79.2)	1.057 (0.672, 1.662)	
Marital Status			
Married	409 (72.8)	ref	
Unmarried	153 (27.2)	1.691 (1.055, 2.709)	*0.029
Total Household Income Level (RM)			
≥1000	139 (24.7)	ref	
0 - 999	423 (75.3)	1.034 (0.674, 1.588)	0.878
Education Level			
Secondary and Higher	71 (12.6)	ref	
Primary and Lower	491 (87.4)	1.312 (0.780, 2.205)	0.306
Employment Status			
Employed	208 (37.0)	ref	
Unemployed	354 (63.0)	1.804 (1.239, 2.625)	*0.002
Handgrip Strength			
Normal	329 (58.5)	ref	
Poor	233 (41.5)	1.136 (0.775, 1.664)	0.513
Waist Circumference			
Normal	185 (32.9)	ref	
Abnormal	377 (67.1)	2.729 (1.865, 3.992)	*<0.001
Body Mass Index (BMI)			
Normal	207 (36.8)	ref	
Overweight	355 (63.2)	2.365 (1.619, 3.455)	*<0.001
Smoking Status			
Never	366 (65.1)	ref	
Ex-smoker	105 (18.7)	1.136 (0.696, 1.853)	0.609
Active	91 (16.2)	1.758 (0.960, 3.219)	*0.067
Alcohol Status			
Never	255 (45.4)	ref	
Ex-drinker	219 (39.0)	0.890 (0.589, 1.344)	0.580
Active	88 (15.7)	0.757 (0.448, 1.277)	0.296
Betel Chewing Status			
Never Chew	321 (57.1)	ref	
Ex-chewer	47 (8.4)	1.537 (0.700, 3.378)	0.284
Active	194 (34.5)	1.104 (0.739, 1.648)	0.630
Depression Status			
No	22 (3.9)	ref	
Mild	377 (67.1)	0.998 (0.394, 2.527)	0.997
Moderate	134 (23.8)	1.827 (0.660, 5.055)	*0.246
Severe	29 (5.2)	0.879 (0.272, 2.838)	0.829

*p < 0.05 considered statistically significant

The associations between various factors and hypertension based on simple logistic regression analysis are presented in Table II.

Regarding physical status, only handgrip strength was found to be an insignificant factor for hypertension, with a p-value of more than 0.05. BMI and waist circumference, on the other hand, were found to have statistical significance in the logistic regression. Those with abnormal waist circumference measurements had an increased odds of 2.7 times (95% CI: 1.865, 3.992; p-value <0.001) of getting hypertension compared to those with standard measurements. Moreover, it was also found that older people with an overweight BMI were more likely to be hypertensive (OR=2.4; 95% CI: 1.619, 3.455; p-value <0.001) compared to the normal BMI category. Social behaviours, including smoking status,

Table III: Factors associated with hypertension among the elderly in Kudat on multivariable logistic regression analysis

Variables	Adjusted OR (aOR) 95% CI	p-value
Age (years old)		
60-69	ref	
70-79	2.685 (1.687, 4.274)	*< 0.001
>80	3.170 (1.548, 6.489)	*0.002
Waist Circumference		
Normal	ref	
Abnormal	2.516 (1.573, 4.022)	*< 0.001
Body Mass Index (BMI)		
Normal	ref	
Overweight	1.873 (1.170, 2.997)	*0.009
Smoking Status		
Never Smoke	ref	
Ex-Smoker	1.229 (0.733, 2.063)	0.434
Active Smoker	2.435 (1.281, 4.626)	*0.007

*p < 0.05 considered statistically significant

alcohol status, betel chewing status and depression status, were found to be statistically not significant at a p-value of more than 0.05 for all four factors.

Table III presents the adjusted odds ratios for significant hypertension-related factors identified through multivariable logistic regression.

In multiple logistic regression, using forward selection, four predictors were included in the model: age, BMI, waist circumference and smoking status. Using backward selection, five predictors were included in the model (age, marital status, BMI, waist circumference and smoking status). However, the p-value for marital status was not a good predictor for the model.17 Variables selected were age, BMI, waist circumference and smoking status. The Nagelkerke R-squared test was 0.136, meaning 13.6% of the hypertension status among the elderly in Kudat could be explained by those factors. Hosmer and Lemeshow tests were run to check for assumptions, resulting in a p-value of 0.335, which was statistically insignificant. The model was deemed fit.

DISCUSSION

In our study, we found that four in every five elderly were hypertensive, with a prevalence of 80.3% among people aged 60 years or older. This figure is comparably higher than the national survey at 69.2% 18 and another study in Selangor, where the prevalence was 53%.[11] The prevalence may be higher for rural communities than urban counterparts. 19 This could be well explained by the limited healthcare facilities available, thus impeding them from getting proper follow-up for their diseases. Awareness and low rate of control among rural dwellers were a concern, too, which would explain the high prevalence of hypertension among them.[20] The vast difference between prevalence in our study compared to national and the state in the Peninsular region indicated that there was a considerable healthcare gap and unmet need for the rural elderly community in Sabah, as they still lack economic stability and social advancement to tackle their health needs, especially the non-communicable diseases.

Risk factors associated with hypertension

Our study significantly concluded that as age increased, they were more likely to have hypertension. The vascular wall's elasticity is lost linearly; thus, thickening of the arterial wall became more prevalent.[21] As a result, the blood pressure was raised inevitably from stiffening, which was the primary consequence of age-related changes in the vasculature of humans. Inevitably, the incidence of cardiovascular disease, mortality, and the rate of decline in renal function were rising tremendously in this population.[22] One study estimated the prevalence of hypertension among the elderly in rural Peninsular Malaysia to be just 54.5%, which was lower than our current finding.[23] A possible explanation for this could be the social and economic environment and development, in addition to the geographical setting, in rural Sabah, which may still be far behind rural Peninsular Malaysia, thus limiting the healthcare awareness and services.[24,25]

Having an abnormal waist circumference increases the likelihood of hypertension. Numerous studies have found a correlation between a larger waist circumference and a higher prevalence of hypertension in Africa [26], China [27], Indonesia[28], and Myanmar[29]. According to a study conducted by the National Health and Nutrition Examination Survey (2004), waist circumference was a more accurate predictor of dyslipidaemia, hypertension, and metabolic syndrome.[30] Waist circumference was a proxy for abdominal obesity, defined as excessive fat deposits in the abdominal region and was independent of the body mass index of the person.[31]

BMI was significantly linked to both hypertension and cardiovascular diseases. Approximately 63% of hypertensive participants in our current study were categorised as overweight. This also included those who were obese. Overweight people were more likely to develop elevated blood pressure by two to three times compared to the average population.[32] These findings are supported by an enormous number of authors and literature worldwide. Urban and rural Africa showed a positive correlation between BMI and raised blood pressure[33], and so was the case among the Chinese population [27] where the risk was 1.7 times higher if overweight and three times higher if obese. In the Indonesian population, those who were overweight had an increased risk

by 1.5 times, but being obese slightly increased the odds by 1.8 times of getting elevated blood pressure compared to people with normal BMI. [28] Those in Myanmar and Nepal also reported a significant association between obesity and hypertension.[29] Hypertension and obesity may be mediated by poor diet and insufficient physical activity.[34]

Smoking was a significant factor in developing hypertension among the elderly community in Kudat, Sabah. Many researchers produced identical reports on the linear effect of smoking on hypertension 35 The effects of nicotine from smoking were quite pronounced in the senior population.[36] Studies showed that nicotine generated adrenaline, noradrenaline, and vasopressin throughout the body and increased the sympathetic nervous system function[37], although the long-term impact was not uniform.

In our study, 27.2% of people with raised blood pressure were unmarried, whether previously divorced or single. The association was found to be statistically significant, as those who were unmarried had a 70% higher risk of getting hypertension compared to the married in univariable analysis. However, in the multivariable model, it was not a significant factor for hypertension. Few studies were also homogenous with ours in that they found the prevalence of raised blood pressure to be significantly associated with being single. 38 It was proposed that, compared to single men, married men have better sleep, less stress, improved moods, and a healthier diet, therefore less chance for CVD risk of hypertension. Divorcees, too, had a similar risk for poor health outcomes. 39

Strengths and Limitations

This study is the first to be carried out among the elderly in rural Sabah to find the factors associated with the prevalence of hypertension. Although few similar studies among older people had been done in Peninsular Malaysia, the results could have differed from those of the Sabahan population. The study tried to find factors which may be specific to the community. The study also included several factors, such as betel nut chewing, depression status and handgrip strength, which were not commonly associated with hypertension previously. In addition, it utilised direct measurement of the participant's physical attributes (BMI, handgrip strength, waist circumference, and blood pressure measurements) with the help of trained volunteers.

There are a few limitations to the study. First, individuals with cognitive impairment were excluded from participation to ensure reliable responses to the questionnaire; this may underestimate the prevalence of known and undiagnosed hypertension among the elderly there. Secondly, using self-reported data through a questionnaire may introduce recall bias, as these elderly may have memory difficulties. They are also subjected to social desirability bias, especially when it is interviewer-assisted. Moreover, due to the selection of a cross-sectional design for this study, no temporality and causality between the independent factors and hypertension could be drawn, limiting the interpretation of the result of the association. Most of the people in the study location are of Rungus ethnicity. They have different cultures, values and dialects. Some of the information or questions in the survey may need to be fully comprehended by them compared to other areas.

Additionally, this study did not examine certain factors that may influence hypertension prevalence, including nutrition, physical activity, comorbidities, stress, and anxiety. Depression was selected as the sole psychological variable due to the wider local validation of depression screening tools compared to stress or anxiety measures, which often require longer instruments and cultural adaptation. This focus helped streamline data collection and minimise respondent burden.

CONCLUSION

In conclusion, this study provided insight into the notably high prevalence of hypertension among the elderly in rural areas of Kudat, Sabah, compared to other previous studies. Several statistically significant factors BMI, waist circumference, smoking status and increasing age were identified highlighting the multifactorial nature of hypertension in later life and highlight the need for integrated risk assessment strategies. Hypertension is becoming a prevailing public health issue globally, whether in developed or developing countries and has been recognised as a risk factor for developing cardiovascular diseases once diagnosed, subsequently contributing to dire health consequences. Given the substantial burden of hypertension and its established link to cardiovascular diseases, these findings reinforce the urgency of implementing a robust screening programme, particularly at the community level. In addition, tailored health education and intervention strategies focusing on modifiable risk factors such as unhealthy weight and smoking are essential to reduce the long-term morbidity and mortality associated with hypertension in this vulnerable population.

Moving forward, public health efforts in rural settings should prioritize accessible and continuous care, enhanced community outreach, and targeted lifestyle interventions to address the growing challenge of hypertension among Malaysia's ageing population.

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REFERENCES

1. Miladinov G. The mechanism between mortality, population growth and ageing of the population in the European lower and upper middle income countries. PLoS One 2021; 16(10): e0258274.
2. Phyo AZZ, Ryan J, Freak-Poli R. The role of health-related quality of life in risk prediction for developing cardiovascular disease, dementia and all-cause death among general older adults. Front Public Health 2022; 10: 1023262.
3. Barrio-Cortes J, Castaño-Reguillo A, Beca-Martínez MT, Bandeira-de Oliveira M, López-Rodríguez C, Jaime-Sisó MÁ. Chronic diseases in the geriatric population: morbidity and use of primary care services according to risk level. BMC Geriatr 2021; 21(1): 438.
4. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Heart disease and stroke statistics—2016 update: a report from the American Heart Association. Circulation 2016; 133(4): e38–48.
5. Bosu WK, Reilly ST, Aheto JMK, Zucchelli E. Hypertension in older adults in Africa: a systematic review and meta-analysis. PLoS One 2019; 14(4): e0214934.
6. Yang ZQ, Zhao Q, Jiang P, Zheng SB, Xu B. Prevalence and control of hypertension among a community of elderly population in Changning District of Shanghai: a cross-sectional study. BMC Geriatr 2017; 17(1): 1-9.
7. Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia. National Health and Morbidity Survey (NHMS) 2019: Non-communicable diseases, risk factors and other health problems. Vol. 1. Kuala Lumpur: Ministry of Health Malaysia; 2019. [cited Jan 2025]. Accessed from: http://www.iku.gov.my/nhms-2019
8. Ab Hamid J, Juni MH, Abdul Manaf R, Syed Ismail SN, Lim PY. Spatial accessibility of primary care in the dual public–private health system in rural areas, Malaysia. Int J Environ Res Public Health 2023; 20(4): 3147.
9. Nan X, Lu H, Wu J, Xue M, Qian Y, Wang W, et al. The interactive association between sodium intake, alcohol consumption and hypertension among elderly in northern China: a cross-sectional study. BMC Geriatr. 2021; 21(1): 636.
10. Lawman HG, Troiano RP, Perna FM, Wang CY, Fryar CD, Ogden CL (2016). Associations of Relative Handgrip Strength and Cardiovascular Disease Biomarkers in U.S. Adults, 2011-2012. American Journal of Preventive Medicine 50(6): 677-683.
11. Lee MR, Jung SM, Kim HS, Kim YB. (2018). Association of muscle strength with cardiovascular risk in Korean adults: Findings from the Korea National Health and Nutrition Examination Survey (KNHANES) VI to VII (2014–2016). Medicine, 97(47).
12. Walston, J. D. (2012). Sarcopenia in older adults. Current Opinion in Rheumatology, 24(6), 623–627.
13. Heck JE, Marcotte EL, Argos M, Parvez F, Ahmed A, Islam T, Sarwar G, Hasan R, Ahsan H, Chen Y. (2012). Betel quid chewing in rural Bangladesh: prevalence, predictors and relationship to blood pressure. International Journal of Epidemiology 41(2): 462.
14. Nikmat AW, Azhar ZI, Shuib N, Hashim NA. (2021). Psychometric properties of Geriatric Depression Scale (Malay version) in elderly with cognitive impairment. Malaysian Journal of Medical Sciences 28(3): 97-104.
15. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source Code Biol Med 2008; 3: 17.
16. Chicco D, Warrens MJ, Jurman G. The coefficient of determination R-squared is more informative than SMAPE, MAE, MAPE, MSE and RMSE in regression analysis evaluation. PeerJ Comput Sci 2021; 7: e623.
17. Ho BK, Omar MA, Sooryanarayana R, Ghazali SS, Zainal Abidin S, Krishnapillai A, et al. Trends in population blood pressure and prevalence, awareness, treatment and control of hypertension among older persons: the 2006 & 2015 National Health and Morbidity Survey in Malaysia. PLoS One 2020; 15(9): e0238780.
18. Wang J, Sun W, Wells GA, Li Z, Li T, Wu J, et al. Differences in prevalence of hypertension and associated risk factors in urban and rural residents of the northeastern region of the People's Republic of China: a cross-sectional study. PLoS One 2018; 13(4): e0195340.
19. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, et al. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high, middle-, and low-income countries. JAMA 2013; 310(9): 959-68.
20. Elisabeth F, Lesmana D, Destanul A. Dominant factor analysis of hypertension in pre-elderly men and women in Puskesmas Rangkapanjaya, Depok City, 2016. PHICo 2017; 1: 308-13.
21. Park JB, Kario K, Wang JG. Systolic hypertension: an increasing clinical challenge in Asia. Hypertens Res 2015; 38(4): 227-36.
22. Rashid AK, Azizah AM. Prevalence of hypertension among the elderly Malays living in rural Malaysia. Australas Med J 2011; 4(6): 283.
23. Bahari MZZ. Seeking balanced development for Sabah, Sarawak. New Straits Times. 2022 Sep 7. [cited Feb 2025]. Accessed from: https://www.nst.com.my/opinion/columnists/2022/09/833279/seeking-balanced-development-sabah-sarawak
24. Azzeri A, Ching GH, Jaafar H, Noor MIM, Razi NA, Then AYH, et al. A review of published literature regarding health issues of coastal communities in Sabah, Malaysia. Int J Environ Res Public Health 2020; 17(5): 1603.
25. Hendriks ME, Wit FWNM, Roos MTL, Brewster LM, Akande TM, de Beer IH, et al. Hypertension in Sub-Saharan Africa: cross-sectional surveys in four rural and urban communities. PLoS One 2012; 7(3): e32638.
26. Yang G, Ma Y, Wang S, Su Y, Rao W, Fu Y, et al. Prevalence and correlates of prehypertension and hypertension among adults in northeastern China: a cross-sectional study. Int J Environ Res Public Health 2015; 13(1): 82.
27. Hussain MA, Al Mamun A, Reid C, Huxley RR. Prevalence, awareness, treatment and control of hypertension in Indonesian adults aged ≥40 years: findings from the Indonesia Family Life Survey (IFLS). PLoS One 2016; 11(8): e0160922.
28. Bjertness MB, Htet AS, Meyer HE, Htike MMT, Zaw KK, Oo WM, et al. Prevalence and determinants of hypertension in Myanmar: a nationwide cross-sectional study. BMC Public Health 2016; 16(1): 590.
29. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. Am J Clin Nutr 2004; 79(3): 379-84.
30. Dhawan D, Sharma S. Abdominal obesity, adipokines and non-communicable diseases. J Steroid Biochem Mol Biol 2020; 203: 105737.
31. Public Health England. Health matters: combating high blood pressure. GOV.UK. 2024. [cited Jan 2025]. Accessed from: https://www.gov.uk/government/publications/health-matters-combating-high-blood-pressure/health-matters-combating-high-blood-pressure
32. Afrifa-Anane E, Agyemang C, Codjoe SNA, Ogedegbe G, De-Graft Aikins A. The association of physical activity, body mass index and the blood pressure levels among urban poor youth in Accra, Ghana. BMC Public Health 2015; 15(1): 269.
33. Esteghamati A, Abbasi M, Alikhani S, Gouya MM, Delavari A, Shishehbor MH, et al. Prevalence, awareness, treatment, and risk factors associated with hypertension in the Iranian population: the national survey of risk factors for noncommunicable diseases of Iran. Am J Hypertens 2008; 21(6): 620-6.
34. Pathak BG, Rahini S, Manapurath RM, Sharath BN, Gupta R, Goel S. Tobacco smoking and blood pressure: how are they related among the Indians? – A secondary analysis of National Family Health Survey (NFHS)-4 data. J Family Med Prim Care. 2022; 11(9): 5776-84.
35. Pickering TG. Effects of stress and behavioral interventions in hypertension—The effects of smoking and nicotine replacement therapy on blood pressure. J Clin Hypertens (Greenwich). 2001; 3(5): 319-21.

36. Li G, Wang H, Wang K, Wang W, Dong F, Qian Y, et al. The association between smoking and blood pressure in men: a cross-sectional study. BMC Public Health 2017; 17(1): 797.
37. Ramezankhani A, Azizi F, Hadaegh F. Associations of marital status with diabetes, hypertension, cardiovascular disease and all-cause mortality: a long term follow-up study. PLoS One 2019; 14(4): e0215593.
38. McCausland FR, Sacks FM, Forman JP. Marital status, dipping and nocturnal blood pressure: results from the Dietary Approaches to Stop Hypertension trial. J Hypertens 2014; 32(4): 766-73.
39. Segawa HK, Uematsu H, Dorji N, Wangdi U, Dorjee C, Yangchen P, et al. Gender with marital status, cultural differences, and vulnerability to hypertension: findings from the national survey for noncommunicable disease risk factors and mental health using WHO STEPS in Bhutan. PLoS One 2021; 16(8): e0256811.