BJMS
Borneo Journal of Medical Sciences

STUDENT'S SECTION

Effects of Hypertension on Cognitive Functions among Rungus Population in Sabah

Jeremy Ling Siew Wei[1*], Liew Seng Yung[1], Ong Sheng Yang[1], Lily Shuzeen Kimin[1], Tamilarasi A/P Sugumaran[1], Pavithran A/L T. Rajanoeran[1], Jennefer Ann[1], Ana Syafiqah[1], Vilasheene A/P S. Vikineswarabalan[1], Ong Jia Ni[1], Nur Syafina[1], Fatin Nurfatihah[1], Nur Athirah[1], Yong Kang Hao[1]

[1] Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

*Corresponding author's email: jeremy0718@outlook.com

Received: 11 January 2018

Accepted: 10 October 2018

Keywords: hypertension, cognitive function, Rungus, MMSE

ABSTRACT

Hypertension is the global disease burden and not only a major risk factor for stroke, but is also crucial risk factor for cognitive impairment and subsequently dementia. However, literature highlighting on cognitive functions is scarce in Malaysia. This study aimed to assess the hypertension and cognitive functions among the Rungus population in rural areas of Kudat, Sabah. A community based cross-sectional study was conducted among population aged 18 and above living in two villages of Kudat. A validated Malay version of Mini-Mental State Examination (M-MMSE) was used to assess cognitive function with cut-off point of 22. Socio-demographic data, risk behaviours (e.g. physical activity level, smoking status and alcohol consumption) and clinical characteristics (e.g. blood pressure, body mass index and waist circumference) were collected. Chi-square and regression model were used for data analysis. A total of 183 respondents participated in this study with a mean age of 44.64 ± 17.26. The prevalence of hypertension was 34.97% and mean score of MMSE was 24.19 ± 5.660. Age, education level, body mass index and waist circumference were significantly associated with hypertension. Hypertension was not significantly associated with cognitive impairment but instead significantly associated with lower performance of MMSE and its language domain. Therefore, comprehensive interventions should be emphasized to have better understandings on hypertension and prevent its damage to cognition.

INTRODUCTION

Hypertension, a well-known disease which has been causing major burden not only in Malaysia but also worldwide[1]. In the past decade, the prevalence of hypertension in Malaysia has risen from 32.3% in 2006 to 32.7% in 2011 with a recent decline to 30.3% in 2015[2]. In Malaysia, diseases of the circulatory systems remain the leading cause of death, constituting of 22.77%[3]. Globally, it is estimated to cause 7.5 million deaths worldwide annually, approximately 12.8% of the total mortality worldwide and account for 57 million disability adjusted life years (DALYS) or 3.7% of total DALYS[4].

Hypertension, apart from being a leading risk factor for stroke, is the single most important modifiable risk factor to the cognitive impairment[5] and subsequently dementia[6]. The prevalence of mild cognitive impairment (MCI) among elderly hypertensives range from 16.63% to as high as 50% in population studies in Malaysia[7]. The MCI conversion rate to diagnosis of dementia is about 10% per year, and it is estimated to have a new case of dementia in every seven seconds worldwide[8]. It is forecasted to have 100% increase in the dementia cases between 2001 and 2040[9]. Thus, to have cognitive decline which is evident at the age of 45 years is not so surprising[10].

Hypertension contributes to cognitive decline and dementia in a multifactorial way though the mechanism is not completely understood. Mild cognitive impairment (MCI) is a clinical entity on its own, rather than a part of normal ageing and is a transitional stage between normal ageing and dementia[11]. It is defined as 'cognitive decline greater than expected for an individual's age and education level but that does not interfere notably with activities of daily life'[12]. Growing literature shows that cerebral vessel dysfunction including impaired auto regulation and neurovascular coupling changes[13] and even cerebral atrophy[14] are essential to MCI pathway.

Therefore, to have blood pressure well controlled and avoiding those associated risk factors, it is hypothesized to delay the onset of mild cognitive impairment. In Malaysia, the literature highlighting on cognitive function is scarce[15 – 17]. To our knowledge, there is no previous study done in Northern Borneo and no studies in Malaysia have recruited young adults as the respondents. This is despite the fact that young and older adults are shown to be more prone to blood pressure-related longitudinal cognitive decline[18]. Therefore, this study aimed to assess the hypertension and cognitive functions among the Rungus population in rural areas of Sabah. Mini Mental State Examination (MMSE) was adopted to assess the cognitive function due to its high sensitivity and specificity with the ease of administration and high inter-rater reliability. The outcome from this study may address a baseline data to serve for comparison within the country and understand how blood pressure relates to cognition prior to clinical dementia so that early identification and effective interventions can be designed.

MATERIALS AND METHODS

This was a cross-sectional analytical study conducted in 2 villages of Kudat, Sabah from 13th September to 28th October 2016. Research proposal was approved by committee panel of Community Medicine Department during community medicine posting of year 4. A purposive non-probability convenience sampling method was done where all villagers aged 18 and above who consented and willing to participate. The data was collected using a set of pre-test standardized self-administered questionnaire through face-to-face interview including socio-demographic characteristics (e.g. age, gender, marital status and education level), physical activity level (PAL), smoking status, alcohol consumption, clinical neuropsychology test, waist circumference and body mass index. All interviewers were trained regarding the

study procedures prior to the conduct of the study. The participants were considered having hypertension if: (1) the average systolic BP ≥140 mmHg and/or average diastolic BP ≥90 mmHg on two readings; (2) or the participants reported a history of hypertension; (3) or participants reported taking anti-hypertensive medications[19]. Men with WC ≥85 cm and women with WC ≥80 cm were abdominally obese[20]. BMI was calculated using equation (BMI = weight in kg/ height in m^2). Objective cognitive assessment was done through a validated Malay version of MMSE[21] with maximum score of 30 as shown in Table 1. Interviewers were briefed and trained by experienced psychiatrist. The cut-off points of MMSE was 22 for Malay-speaking population[7, 22].

Table 1 Items incorporated within each domain of MMSE

Domains	Items incorporated within domain
Orientation domain	Temporal orientation
	Spatial orientation
Registration domain	Immediate memory
Attention and calculation domain	Attention and calculation ability
Recall domain	Delayed recall
Language domain	Naming objects
	Repetition
	Language comprehension
	Reading
	Writing
Copying domain	Visual-spatial and executive ability

The data collected was recorded and computed by using Statistical Packages of Social Sciences (SPSS), Window version 23.0. The socio-demographic details and clinical characteristics of the respondents and the mean scores for MMSE and its each domain were tabulated for the descriptive analysis. Numerical data are reported as mean (± SD) while categorical data are reported as the number of cases (percentage). Chi-square and multivariate regression model were used to establish the relationship between hypertension status and its associated factors and also its association with MMSE and its each domain. The results were expressed as odds ratio and confidence interval. *P*-value of less than 0.05 was considered statistically significant.

RESULTS

Out of 509 residents in the two villages, 262 are 18 years old and above. A total of 183 participated in our study, giving 69.85% response rate. Among them, 41.5% were males and 58.5% were females with the mean age of 44.64 ± 17.26 years. Among the interviewed respondents, Rungus (88.5%) was the predominant ethnicity in this study and the remaining are Dusun (1.64%), Chinese (1.09%), Iban (0.55%) and Ubian (0.55%). The age 40 – 49 (24.04%) was the predominant age group while elderly population with age ≥60 was large (21.86%) under the current study (Figure 1). Besides, most were Christians (90.7%), married (77.0%) and had education up to secondary education (40.4%). Also, 74.3% of them were currently working and had mean income of RM390.57 ± 674.57 with 167 (91.3%) of them below poverty line index (less than RM1,080).

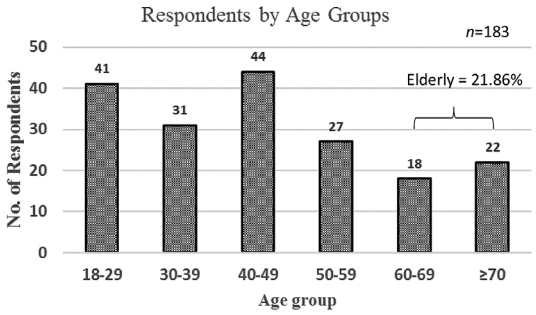

Figure 1 Age distribution among the respondents

In the present study, it was found that 34.97% (*n* = 64) of them were hypertensive while the remaining 65.03% (*n* = 119) were normotensive and female had higher prevalence of hypertension (39.25%) than male (28.95%) as depicted in Figure 2.

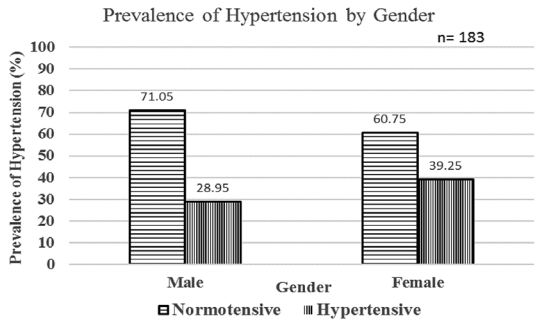

Figure 2 Prevalence of hypertension with gender

With regards to risk behaviours, most of them were neither smoker (77.6%) nor drinking alcohol (91.8%). Majority of them were considered as practising high physical activity level (37.7%) but it was found that 65.0% of them had abnormal BMI and 50.8% were centrally obese (Table 3).

Table 2 Baseline data on MMSE score

MMSE domain	Mean ± Standard deviation
Orientation domain	10.0 ± 9.07
Registration domain	2.54 ± 1.004
Attention and calculation domain	3.35 ± 2.122
Recall domain	1.78 ± 1.279
Language domain	6.73 ± 1.661
Copying domain	0.73 ± 0.444
Total MMSE score	24.19 ± 5.660

Concerning on the cognitive functions, it was found that the total MMSE score among the respondents was 24.19 ± 5.660 which was considered as having normal cognitive function. The median of cognitive score was the highest among the normotensive groups which was 27, 3 scores higher than hypertensive group (Table 2).

Table 3 Association between hypertension and the variables

Variables		Hypertensive status (*n* = 183)		*P* value	OR (95% CI)
		Yes (*n* = 64)	No (*n* = 119)		
Age groups	18 – 29	3 (1.6%)	38 (20.8%)	<0.001**	1
	30 – 39	5 (2.7%)	26 (14.2%)		2.436 (0.535 – 11.091)
	40 – 49	14 (7.7%)	30 (16.4%)		5.911 (1.555 – 22.477)
	50 – 59	16 (8.7%)	11 (6.0%)		18.424 (4.526 – 75.005)
	60 – 69	9 (4.9%)	9 (4.9%)		12.667 (2.840 – 56.489)
	≥ 70	17 (9.3%)	5 (2.7%)		43.067 (9.220 – 201.165)
Gender	Male	22 (12.0%)	54 (29.5%)	0.150	0.631
	Female	42 (23.0%)	65 (35.5%)		(0.336 – 1.183)
Marital status	With partner	54 (29.5%)	87 (47.5%)	0.084	1.986
	Single/ Divorced/ Widowed	10 (5.5%)	32 (17.5%)		(0.904 – 4.364)
Education level	No formal education	30 (16.4%)	16 (8.7%)	<0.001**	9.844 (2.879 – 33.658)
	Primary education	14 (7.7%)	24 (13.1%)		3.062 (0.872 – 10.754)
	Secondary education	16 (8.7%)	58 (31.7%)		1.448 (0.434 – 4.828)
	Tertiary education	4 (2.2%)	21 (11.5%)		1
Education	Education years [Mean ± SD, y]	4.56 (±5.030)	8.83 (±4.732)		–

Working status	Yes	45(24.6%)	91 (49.7%)	0.363	0.729
	No	19 (10.4%)	28 (15.3%)		(0.368 – 1.443)
Household income	Below poverty line index	60 (32.8%)	107 (58.5%)	0.381	1.682 (0.520 – 5.447)
	Above poverty line index	4 (2.2%)	12 (6.6%)		
Smoking status	Yes	11 (6.0%)	30 (16.4%)	0.215	0.616
	No	53 (29.0%)	89 (48.6%)		(0.285-1.330)
Alcohol consumption	Yes	5 (2.7%)	10 (5.5%)	0.889	0.924
	No	59 (32.2%)	109 (59.6%)		(0.302 – 2.829)
Physical activity level	Low	21 (11.5%))	33 (18.0%)	0.417	1.559 (0.733 – 3.317)
	Moderate	23 (12.6%)	37 (20.2%)		1.523 (0.730 – 3.178)
	High	20 (10.9%	49 (26.8%)		1
Body mass index (BMI)	Underweight	5 (2.7%)	6 (3.3%)	0.003*	4.015 (1.038 – 15.533)
	Normal	11 (6.0%)	53 (29.0%)		1
	Overweight	32 (17.5%)	42 (23.0%)		3.671 (1.657 – 8.135)
	Obese	16 (8.7%)	18 (9.8%)		4.283 (1.680 – 10.915)
Waist circumference (cm)	Central obesity	45 (24.6%)	48 (26.2%)	<0.001**	3.503
	Normal	19 (10.4%)	71 (38.8%)		(1.830 – 6.706)

*Significant at $p < 0.05$
**Significant at $p < 0.001$

There were statistically significant relationships between hypertension and age groups ($p < 0.001$), education level ($p < 0.001$), body mass index ($p = 0.003$) and waist circumference ($p < 0.001$) based on Table 3.

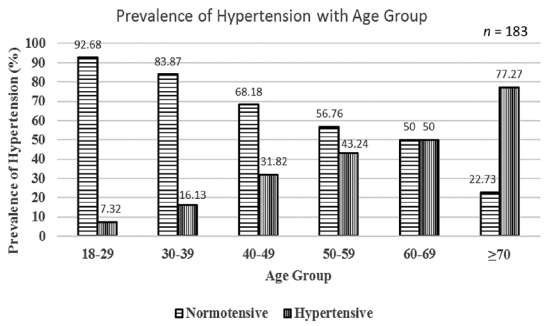

Figure 3 Prevalence of hypertension with age group

For age groups, the proportion of hypertension increased with increasing age. A clear positive association between age groups and hypertension can thus be seen (Figure 3).

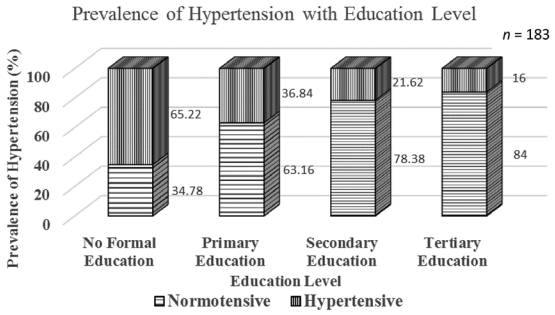

Figure 4 Prevalence of hypertension with education level

In terms of education level, those with tertiary education had the lowest prevalence of hypertension (16%), followed by secondary education (21.62%), primary education (36.84%) and those without formal education (65.22%) as shown in Figure 4.

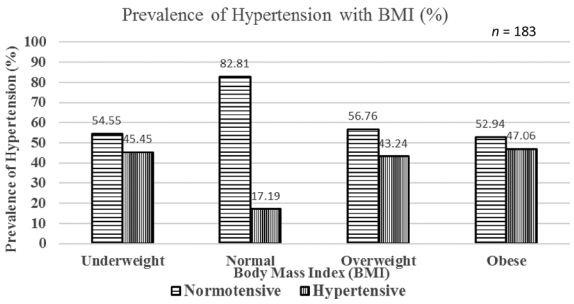

Figure 5 Prevalence of hypertension with BMI

Besides, respondents with abnormal BMI were more likely to have hypertension as depicted in Figure 5. Hypertension prevalence was the lowest (17.19%) among normal BMI group and the highest (47.06%) among the obese group (Figure 5).

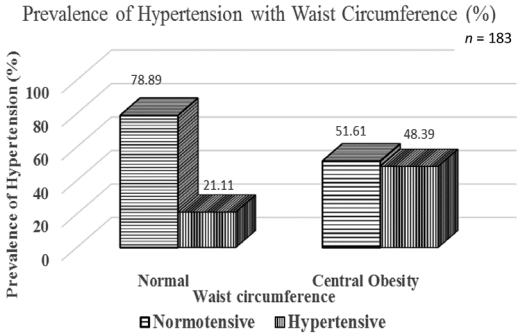

Figure 6 Prevalence of hypertension with waist circumference

Those with central obesity was significantly associated with hypertension (OR: 3.503) when compared to those without central obesity (Figure 6).

Table 4 Association between hypertension and cognitive function

Variables	Cognitive Function		d*f*	*P* value	Adjusted odds ratio	95% confidence interval
	Cognitive impairment	Normal				
Hypertension						
Yes	28 (15.3%)	36 (19.7%)	1	0.052	2.815	0.992 – 7.989
No	13 (7.1%)	106 (57.9%)				

Adjusted for age and education
*Significant at $p < 0.05$

It was found that there was no significant association between hypertension and cognitive impairment ($p = 0.052$) as shown in Table 4.

Table 5: Association between Hypertension and MMSE and its Domains

Variables	Total MMSE	Orientation	Registration	Attention and Calculation	Recall	Language	Copying
Hypertensive status B coefficients (95% CI)	−1.817 (−3.322 – −0.313)	−0.417 (−0.892 – 0.058)	−0.102 (−0.453 – 0.250)	−0.417 (−1.145 – 0.310)	−0.274 (−0.698– 0.150)	−0.652 (−1.104 – −0.200)	0.033 (−0.088 – 0.154)
Sig.	$p = 0.018$*	$p = 0.085$	$p = 0.569$	$p = 0.259$	$p = 0.204$	$p = 0.005$*	$p = 0.588$

Adjusted odds ratio for age and education
*Significant at $p < 0.05$

However, those with hypertension were significantly associated with lower performance on total MMSE. It was thus can be concluded that total MMSE score was 1.817 lower among those who were hypertensive compared to those who were normotensive. Apart from that, those who were hypertensive more likely to have 0.652 lower score in language domain when compared to normotensive respondents (Table 5).

DISCUSSION

The present study aimed to identify the risk factors associated with hypertension and its effect in terms of cognitive function among Rungus population in the rural areas of Northern Borneo. The prevalence of hypertension among the respondents in the present study was 34.97 % which was slightly higher than that of rural population in Malaysia according to a national survey in 2015 (33.5%) [2]. Apart from that, it was found that 21.8% of the study population was 60 years old and above, which was significantly higher when compared to the current elderly population in Malaysia[3]. This study generally demonstrated that the prevalence of hypertension increased with age and the age groups 40 – 49 (OR 5.911), 50 – 59 (OR 18.424), 60 – 69 (OR 12.667), 70 and above (OR 43.067) had significant higher risk of getting hypertension when compared to age group 18 – 29. The same trend was found in a study done in northern west Malaysia and was consistent with other studies[11, 23, 24]. There is a general agreement that with increasing life expectancy, people prone to develop diseases, thus associated with high prevalence of hypertension as in the current study in view of high proportion of elderly population[19 – 22].

Rungus, the population weighed less than 1% in the total population of Malaysia[25], making up 88.5% of the study population under the current study. In this study, education level was significantly associated with hypertension among the respondents and was shown that illiterate had higher risk of hypertension when compared to those with tertiary education ($p < 0.001$, OR 9.844). This was consistent with the findings of previous studies[1, 23]. This was probably due to lack of awareness and knowledge on hypertension, thus reduce the chance of the early diagnosis and early treatment which was supported by high prevalence of not known hypertension among hypertensive respondents (43.75%) in the current study as most hypertension is asymptomatic. These findings indicate the needs of delivery of health education to the low educational level committee.

Another significant association was that both increase in BMI and waist circumference are significantly associated with hypertension which concurred with previous studies[23, 24]. Urbanization and improved socioeconomic status, sedentary lifestyle and unhealthy dietary habits had led to obesity. Malaysia has the highest prevalence of obesity in Southeast Asia and 49% of women and 44% of men in this country were found to be obese[26]. Obese individuals have more fatty tissue that increases their vascular resistance and in turn increases the heart workload to pump blood throughout the body and hypertension results when systemic vascular resistance fails to decrease and unable to cope with the increase of cardiac output[27]. Thus, it was important to emphasize on the weight reduction as it was modifiable and preventable risk factor for hypertension.

It is interesting to mention our study has not only found significant association between high BMI and hypertension, but also lower-than-normal BMI and hypertension which was similar with other studies[28, 29]. In our study, the occurrence of underweight of villagers may exist since childhood, thus it may be the cause of hypertension in their adult life. It was proved that malnutrition during early childhood would lead to underdevelopment of the arterial tree due to low cardiac output and consequently hypertension in adult life. Therefore, concern on malnutrition during development or childhood period could not be emphasized enough.

Alcohol, a well-known risk factor for non-communicable diseases and was shown that excessive consumption was associated with an increased risk of hypertension, stroke and certain cancers[23]. However, the alcohol consumption ($p = 0.889$, OR 0.924) in this study was not significantly associated with hypertension, owing to low proportion of

consuming alcohol (8.2%). It was also found that smokers had lower odds of having hypertension ($p = 0.215$, OR 0.616) as compared to non-smokers which was later proved to be insignificant due to less smokers in the present study despite the well-known facts of smoking increase the risk of pre-hypertension and hypertension.

In the current study, hypertension was not significantly associated with cognitive impairment ($p = 0.052$). Such inconsistencies were likely due to different inclusion criteria, study design, sample size, cognitive assessment method and language limitation. Nevertheless, hypertension was significantly associated with lower performance in total MMSE score ($p = 0.018$, *B* coefficients: −1.817) and language domain ($p = 0.005$, *B* coefficients: −0.652) in the current study.

It was suggested that hypertension-induced microvascular changes situated primarily in frontal system white matter[30], causing language impairment. Another reason could be the usage of Malay version MMSE, which limits the understandings and linguistic proficiency for some elderly respondents.

CONCLUSION

Prevalence of hypertension was high among elderly and low-educated population. Undiagnosed hypertension was also high among hypertensive respondents. Abnormal BMI and central obesity were significantly associated with higher risk of hypertension. With respect to cognitive function, hypertension was significantly associated with lower performance of MMSE and its language domain. A comprehensive interventions and efforts are crucial to have better understandings on hypertension and prevent damage on the cognition.

LIMITATIONS

The sample size was small ($n = 183$), which limits the statistical power to detect the true effect. The age of the population in this study had also great variant compared to previous studies which were more focused on the elderly group of population. There was also limitation in choosing cross-sectional study to study the chronicity and long-term effects of the hypertension. While non-probability convenience sampling was employed in the present study, its vulnerability to severe hidden biases could not be neglected. The validated Malay version Mini Mental State Examination (MMSE) adopted in the current study had language limitations as the main language of some elderly respondents was Rungus. Despite of the limitations, this community based cross-sectional study gives valuable information on the hypertension and cognitive function among Rungus population. Future research should sample larger numbers of persons with controlled, untreated, and uncontrolled hypertension and efforts should be put to generate a Rungus version MMSE to ease the process and obtain accurate results.

ACKNOWLEDGEMENTS

Special thanks to the lecturers of Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Assoc. Prof. Dr Than Myint, Assoc. Prof. Dr Tin Tin Aye, Assoc. Prof. Dr Daw Khin Saw Naing and Dr Wendy Diana Shoesmith for their encouragement and guidance throughout the process of this research.

CONFLICT OF INTEREST

The authors declare that they have no competing interests in publishing this paper.

REFERENCES

1. Naing C, Yeoh PN, Wai VN et al. (2016). Hypertension in Malaysia: An analysis of trends from the national surveys 1996 to 2011. Medicine 95 (2): 1 – 7.
2. National Health and Morbidity Survey 2015. (2015). Volume II: Non-communicable diseases, risk factors & other health problems. Kuala Lumpur, Malaysia: Institute for Public Health.
3. Ministry of Health Malaysia. (2016). Health Facts 2016. Putrajaya Malaysia: MOH Publications.
4. World Health Organization (WHO). (2016). Global Health Observatory (GHO) data, Raised blood pressure - Situation and trends. http://www.who.int/gho/ncd/risk_factors/blood_pressure_prevalence_text/en/ (accessed October 10, 2016).
5. Shang S, Li P, Deng M et al. (2016). The Age-Dependent Relationship between Blood Pressure and Cognitive Impairment: A Cross-Sectional Study in a Rural Area of Xi'an, China. PLoS ONE 11 (7): 1 – 18.
6. Stefan Knecht, Heike Wersching, Hubertus Lohmann et al. (2009). How much does hypertension affect cognition? Explained variance in cross-sectional analysis of non-demented community-dwelling individuals in the SEARCH study. Journal of the Neurological Sciences 283 (2009): 149 – 152.
7. Khairiah K, Mooi CS, Hamid TA. (2016). Prevalence and Factors Associated with Mild Cognitive Impairment on Screening in Older Malaysians. Düşünen Adam: The Journal of Psychiatry and Neurological Sciences 29 (4): 298 – 306.
8. Eshkoor SA, Hamid TA, Mun CY et al. (2015). Mild cognitive impairment and its management in older people. Clinical Interventions in Aging 10: 687 – 693.
9. Ferri CP, Prince M, Brayne C et al. (2005). Global prevalence of dementia: A Delphi consensus study. The Lancet 366(9503): 2112 – 2117.
10. Singh-Manoux A, Kivimaki M, Glymour MM et al. (2012). Timing of onset of cognitive decline: results from Whitehall II prospective cohort study. BMJ 344: 1 – 8.
11. Razali R, Baharudin A, Jaafar NRN et al. (2012). Factors Associated with Mild Cognitive Impairment among Elderly Patients Attending Medical Clinics in Universiti Kebangsaan Malaysia Medical Centre. Sains Malaysiana 41 (5): 641 – 647.
12. Gauthier S, Reisberg B, Zaudig M et al. (2006). Mild cognitive impairment. The Lancet 367 (9518): 1262 – 1270.
13. Cherubini A, Lowenthal DT, Paran E et al. (2010). Hypertension and Cognitive Function in the Elderly. Disease-a-Month 56 (3): 106 – 147.
14. Sharma M, Kupferman JC, Brosgol Y et al. (2010). The effects of hypertension on the paediatric brain: a justifiable concern. The Lancet Neurology 9 (9): 933 – 940.
15. Won H, Singh DKA, Din NC et al. (2014). Relationship between physical performance and cognitive performance measures among community-dwelling older adults. Clinical Epidemiology 2014 (6): 343 – 50.
16. Rashid AK, Azizah AM, Rohana S. (2012). Cognitive impairment among the elderly Malays living in rural Malaysia. The Medical Journal of Malaysia 67 (2): 186 – 189.
17. A Rashid K, Narayan KA, Azizah AM. (2006). The prevalence of cognitive impairment and depression and their associated factors in an elderly population in two villages in Kedah, Malaysia. Malaysian Journal of Public Health Medicine 6 (1): 29 – 37.
18. Penelope K. Elias, Merrill F. Elias, Michael A. Robbins et al. (2004). Blood Pressure-Related Cognitive Decline Does Age Make a Difference? Hypertension 44 (5): 631 – 636.
19. Rampala L, Rampal S, Azhar MZ et al. (2008). Prevalence, awareness, treatment and control of hypertension in Malaysia: A national study of 16,440 subjects. Public Health 122 (1): 11 – 18.
20. Health Technology Assessment Section, Medical Development Division Ministry of Health, Malaysia. (2004). Clinical Practice Guideline on Management of Obesity. Putrajaya: Ministry of Health, Malaysia
21. Zarina ZA, Zahiruddin O, Che Wan AH. (2007). Validation of Malay Mini Mental State Examination. Malaysian Journal of Psychiatry 16 (1): 16 – 19.
22. Ibrahim NM, Shohaimi S, Chong HT et al. (2009). Validation study of the Mini-Mental State Examination in a Malay-speaking elderly population in Malaysia. Dement Geriatr Cogn Disord 27 (3): 247 – 253.
23. Tee SR, Teoh XY, Aiman WA et al. (2010). The Prevalence of Hypertension and Its Associated Risk Factors In Two Rural Communities In Penang, Malaysia. International e-Journal of Science, Medicine & Education (IeJSME) 4 (2): 27 – 40.

24. Abdul-Razak S, Daher AM, Ramli AS et al. (2016). Prevalence, awareness, treatment, control and socio demographic determinants of hypertension in Malaysian adults. BMC Public Health 16: 351.
25. Department of Statistics Malaysia. (2016). Current Population Estimates, Malaysia, 2014 – 2016. Department of Statistics Malaysia.
26. Ng M, Fleming T, Robinson M et al. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet 384 (9945): 766 – 781.
27. Aniza I, Hayati K, Juhaida MN et al. (2015). Obesity Related Hypertension– Gender Specific Analysis among Adults in Tanjung Karang, Selangor, Malaysia. Malaysian Journal of Public Health Medicine 15 (1): 41 – 52.
28. Ravisankar P, Madanmohan, Kaviraja Udupa et al. (2005). Correlation between Body Mass Index and Blood Pressure Indices, Handgrip Strength and Handgrip Endurance in Underweight, Normal Weight and Overweight Adolescents. Indian J Physiol Pharmacol 49 (4): 455 – 461.
29. Tesfaye F, Nawi NG, Van Minh H et al. (2007). Association between body mass index and blood pressure across three populations in Africa and Asia. Journal of Human Hypertension 21 (1): 28 – 37.
30. Cahana-Amitay D, Albert ML, Ojo EA et al. (2009). Effects of Hypertension and Diabetes on Sentence Comprehension in Aging. Journals of Gerontology, Series B: Psychological Sciences and Social Sciences 68 (4): 513 – 521.