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Title page

Prevalence of stroke, risk factors, disability, and care needs in older adults in Singapore: Results from the WiSE study

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Abstract

Objectives: The aims of the present study were to establish the prevalence of stroke, and to explore the association between stroke prevalence and socio-demographic, health factors, disability, cognitive functioning, and care needs among older adult residents in Singapore.

Setting: Data was drawn from the Well-being of the Singapore Elderly (WiSE) study - a cross-sectional epidemiological survey conducted from 2012 to 2013 on older adults living in Singapore.

Participants Singapore residents (Citizens and permanent residents) 60 years and above who were living in Singapore at that point of time. Older adult residents who were institutionalized were also included in this study. Those who were not living in Singapore or who were not contactable were excluded from the study. A total population sample of 2562 participants completed the survey. The response rate was 65.6%. Participants comprised 43.6% males and 56.4% females. The sample comprised 39.4% Chinese, 29.1% Malay, 30.1% Indian, and other ethnicities 1.4%.

Primary and secondary outcome measures: Stroke, along with other health and mental health conditions, disability and cognitive functioning, were determined by self-report.

Results: Weighted stroke prevalence was 7.6% among older adults aged 60 and above. At a multivariate level, Malay ethnicity (OR=0.41 *p*=0.012 95%CI[0.20, 0.82]) , hypertension (OR=4.58, *p*=0.001, 95%CI[1.84, 11.40]) , heart trouble (OR=2.45, *p*=0.006, 95%CI[1.30, 4.63]), diabetes (OR=2.60, *p*=0.001, 95%CI[1.49, 4.53]) and dementia (OR=3.57, *p*=0.002, 95%CI[1.57, 8.12]) were associated with stroke prevalence.

Conclusions: Several findings of this study were consistent with previous reports. Given that Singapore's population is ageing rapidly, our findings may indicate the need to review existing support services for stroke survivors and their caregivers. Future research could investigate the association between various sociodemographic and health conditions and stroke prevalence to confirm some of the findings of this study.

Keywords: stroke prevalence, stroke risk factors, epidemiology, south-east Asia, multi-ethnic

Article Summary

Strengths and limitations

- Stroke estimates reported in this study contributes to the paucity of research on stroke epidemiology in a rapidly ageing multi-ethnic Singapore.
- This study examined self-reported stroke which may be subjected to errors such as false reporting resulting in over or under-estimation of stroke prevalence.
- As this is a cross-sectional study, temporal relationships between stroke and other factors cannot be established

Background

Stroke is defined as "a neurological deficit attributed to an acute focal injury of the central nervous system (CNS) by a vascular cause"[1]. Older age and the male gender are associated with greater stroke risk[2]. Health conditions such as hypertension, cardiovascular diseases, and diabetes are established risk factors of stroke[3]; whereas lifestyle factors such as smoking, alcohol consumption and obesity are found to contribute to stroke risk, some of which are dose-dependent [4]. Depression and dementia have also found to be associated with stroke[5, 6].

Stroke is one of the leading causes of disability and disease burden worldwide[7]. Despite the global severity of stroke, stroke prevalence estimates outside Western, South Asian or East Asian regions are less readily available[8, 9]. Establishing stroke prevalence estimates are important in providing feedback and planning of stroke rehabilitation and prevention, and stroke data from Asian regions provide a basis for comparison against Western estimates and trends[10]. Recent stroke estimates from multi-racial Asian populations such as those in South-east Asia are lacking. Thus, more data is needed to ascertain stroke prevalence in Asian populations with diverse ethnic communities.

Singapore has a resident population of 3.93 million[11]. The population comprises 74.3% Chinese, 13.4% Malay, 9.1% Indian and 3.2% other ethnicities. Singapore's population is ageing mainly due to an increase in the life expectancy - 82.7 years in 2015 from 65.8 years in 1970[12]. Singapore's older adult residents (defined as Singapore citizens and permanent residents aged 65 and above) constitute 12.4% of the resident population, which is an increase from 7.2% in the year 2000[11, 13]. The prevalence of chronic diseases including stroke is expected to be higher among this ageing population.

The aims of the current study were: 1) to establish the prevalence of stroke among adults aged 60 years and above in Singapore, 2) to explore the correlation of stroke with socio-demographic factors and health conditions, and 3) to explore the association of stroke with disability, cognitive functioning, and care needs.

Methods

This study used data from the Well-being of the Singapore Elderly (WiSE) study which was conducted from October 2012 to December 2013. The WiSE study was approved by the institutional ethics review boards: National Healthcare Group Domain Specific Review Board and the SingHealth Centralised Institutional Review Board. Participants provided written consent to participate in this study.

The overall sample comprised of older adult Singapore residents (Singapore citizens and permanent residents) aged 60 years and above, who were living in Singapore at that point of time. Older adult residents who were institutionalized were also included in this study. Those who were not living in Singapore or who were not contactable were excluded from the study.

Sampling was conducted at random using a disproportionate stratified sampling design where the Malays and Indians, and those aged 75 and above were oversampled so as to increase precision of subgroup estimation. To ensure that the results of the WiSE study are generalizable to the older adult population in Singapore, the results were weighted against the older adult resident population of 2011.

Participants who consented to the study were administered a series of questionnaires which comprised questions on socio-demographics, health, cognition, and neurological tests in a single assessment. For each participant, an informant was also chosen and administered informant-adapted questionnaires. An informant was defined as the "person who knows the older person best". Some informants were caregivers whilst others were in close contact with the older person without a caregiving role. The assessments were carried out based on the participants' preferred language or dialect and were conducted by trained interviewers. The questionnaires were valid, reliable and made culturally relevant for the older adults in Singapore. An earlier article[17] provides further details of the study.

The main questionnaires relevant to this current analysis were:

Socio-demographic questionnaire: Participants were asked to provide socio-demographic information such as their age, education level, and height and weight measurements.

Stroke and health conditions: Participants were asked if they had ever been told by a doctor that they had stroke. Participants were questioned in the same way for other health conditions such as hypertension, heart trouble, and diabetes. Additionally, they were asked to provide more details about who diagnosed their health condition and whether they were still seeking treatment for the condition.

Smoking: Participants provided a response for the following question, "Has there ever been a period when you smoked cigarettes, cigars, or a pipe, chewing tobacco, beedi (Indian cigarette) or snuff nearly every day?", responses were binary 0 (No) and 1 (Yes) and, "Do you still use tobacco regularly?", responses were binary 0 (No) and 1 (Yes). Responses for the 2 questions were then categorized into 0 (Non-smoker), 1 (Ex-smoker) and 2 (Current smoker).

Alcohol use: Participants provided responses for the following question, "Was there ever a period in your life when you drank at least 12 drinks in a year?" Responses were 0 (Never drank alcoholic drinks), 1 (No, less than 12 drinks in a year), 2 (Yes, more than 12 drinks a year). Responses were recoded as 0 (Never drank alcoholic drinks), original responses 1 and 2 were recoded as 1 (Yes, ever drank alcoholic drinks).

Body Mass Index (BMI) and Waist-Hip-Ratio (WHR): Body mass index was calculated by the division of weight with height. Those with BMI ≥30kg/m were considered obese[15]. Waist-hip-ratio is a measurement of abdominal obesity, measured by a ratio of waist to hip circumference. Males with waist-hip-ratio greater than 0.90 and females greater than 0.80, were considered to be obese[14].

Geriatric Mental State-Automated Geriatric Examination for Computer Assisted Taxonomy (GMS-AGECAT, Depression): A diagnostic assessment for depression as well as other mental illnesses that uses a computerized algorithm (AGECAT) to make diagnoses. 5 levels of severity are generated from 0 (none) to 5 (severe). A severity level 0 would indicate no depression; levels 1-3 indicate subsyndromal depression, levels 4-5 indicate DSM-IV depression. For the purpose of this analysis, responses were recoded as binary responses 0 (levels 1-3), 1 (levels 4 and 5). Inter-rater agreement on depression diagnoses between AGECAT and psychiatrists' achieved a kappa value of 0.88[15].

A cognitive test battery comprising two cognitive tests, a) the community screening instrument for dementia (CSI'D) which incorporated the animal naming verbal fluency task by the Consortium to Establish a Registry for Alzheimer's Dementia (CERAD), and b) a 10 word-list learning task with delayed recall by CERAD (modified). An aggregated score (COGSCORE) was generated by taking the summation of all item-weighted scores of the entire cognitive test battery.

10/66 Dementia: A 10/66 dementia diagnosis was given to older adults based on a cut-off determined by logistic regression coefficients of CSI'D COGSCORE, RELSCORE (unweighted total informant score of functional and cognitive decline in the older adult), GMS/AGECAT, and the modified CERAD. A cut-off of more than 0.25 was used as it produced the best sensitivity and specificity to identify dementia cases[16]. Validation of the 10/66 diagnosis revealed that it had a substantial agreement with clinician diagnosis in the WiSE study[17].

World Health Organisation-Disability Assessment Schedule (WHO-DAS) 2.0: It is a 12-item questionnaire which assesses 6 domains of functioning in cognition, mobility, self-care, getting along, life

activities and participation (WHODAS). Item responses range from 0 (no difficulty) to 4 (extremely difficulty or cannot do). A total WHO-DAS score is calculated by the summation of the domain scores.

Care need: defined as the amount of care needed by the older person that is provided by the informant. Informants were asked to respond to whether: the older person needs care much of the time (1), needs care occasionally (2), does not need care; they are able to do everything for themselves (3).

Statistical Analysis

Statistical analyses were carried out using the SAS System version 9.3. All of the statistical analyses used in this study were based on weighted data. First, simple logistic regression was used to analyze the correlates of stroke prevalence at a univariate level. Second, multiple logistic regression was used to analyze socio-demographic and health correlates of stroke at a multivariate level. Socio-demographic factors such as age group, gender, ethnicity, education and health or lifestyle conditions such as hypertension, heart trouble, diabetes, smoking, alcohol use, depression and dementia were used as predictors in both regression analyses. Associations with cognitive and disability scores were estimated using multiple linear regressions, while association with care needs was estimated using multinomial logistic regression after accounting for covariates. Statistical significance was set at a conventional cut-off point at P<.05, two-tailed.

The target sample size was determined by a power calculation for binary proportions. After adjusting for design effect for the overall prevalence estimate, subgroups by age and ethnicity with the precision of 5%, it was estimated that a sample size of 2500 was sufficient in providing adequate precision in measuring the study's main objectives of dementia prevalence [17].

Results

The characteristics of the sample population were summarized in table 1. In all, 2562 participants were included in the current analysis. Participants comprised 43.6% males and 56.4% females. The sample comprised 39.4% Chinese, 29.1% Malay, 30.1% Indian, and other ethnicities 1.4%.

Variable	Category	n	%	SE
Age group	60-74	1493	75.1	0.02
	75-84	668	19.4	0.02
	85+	401	5.5	0.01

Gender	Men	1116	44.1	1.41
	Women	1446	55.9	1.41
Ethnicity	Chinese	1009	83.3	0.03
	Malay	745	9.3	0.01
	Indian	772	6.0	0.02
	Others	36	1.4	0.01
Education	None	510	16.4	0.98
	Some, but did not complete primary	620	24.0	1.21
	Completed primary	639	24.8	1.23
	Completed secondary	517	22.4	1.20
	Completed tertiary	262	12.4	0.97
Smoking	No	1888	74.5	1.21
	Ex-smoker	438	15.9	0.99
	Current smoker	236	9.5	0.83
Body-Mass-Index (BMI)	<30 kg/m (Not obese)	1969	91.4	0.75
	≥30kg/m (Obese)	318	8.6	0.75
Waist hip ratio (WHR)	Low	401	20.2	1.20
	High	1924	79.8	1.20
Drinkers	No	1579	48.2	1.40
	Yes	983	51.8	1.40
GMS Depression	Yes	176	3.7	0.45
	No	2386	96.3	0.45
Hypertension	No	1010	40.6	1.39
	Yes	1549	59.4	1.39
Heart problem	No	2106	86.7	0.90
	Yes	449	13.3	0.90
Diabetes	No	1756	74.5	1.21
	Yes	798	25.5	1.21
10/66 dementia	No	2021	90.0	0.70
	Yes	398	10.0	0.70

Out of 2562 older adult participants, 199 respondents reported that they had ever been told by a doctor to have had stroke. Missing answers were deleted listwise. The overall weighted stroke prevalence was 7.6% among older adult residents aged 60 years and above. Weighted stroke prevalence for those aged 65 years and above was 9.3%. A detailed breakdown of the prevalence of stroke by socio-demographic and health variables were presented in table 2.

Table 2. Number of stroke and non-stroke cases by sociodemographic and health factors.

		Without stroke			Stroke		
Variable	Category	n	%	SE	n	%	SE

Age group	60-74	1415	94.3	0.8	78	5.7	0.8
	75-84	599	87.4	1.8	69	12.6	1.8
	85+	349	84.5	2.4	52	15.5	2.4
Gender	Men	1033	92	1.1	83	8	1.1
	Women	1330	92.7	0.9	116	7.3	0.9
Ethnicity	Chinese	913	92.2	0.8	96	7.8	0.8
Table 2 (cont'd).							
	Malay	704	94.9	0.9	41	5.1	0.9
	Indian	715	93.7	0.9	57	6.3	0.9
	Others	31	85.6	6.1	5	14.4	6.1
Education	None	455	87.8	2.1	55	12.2	2.1
	Some, but did not complete primary	566	91.8	1.5	54	8.2	1.5
	Completed primary	596	93.4	1.4	43	6.6	1.4
	Completed secondary	485	93.7	1.4	32	6.3	1.4
	Completed tertiary	249	95.5	1.7	13	4.5	1.7
Smoking	No	1749	93.2	0.8	139	6.8	0.8
	Ex-smoker	393	87.7	2.2	45	12.3	2.2
	Current smoker	221	93.8	2.2	15	6.2	2.2
BMI	<30 kg/m (Not obese)	1850	94.1	0.7	119	5.9	0.7
	≥30kg/m (Obese)	304	94.1	2.3	14	5.9	2.3
WHR	Low	382	96	1.2	19	4	1.2
	High	1809	93.5	0.8	115	6.5	0.8
Drinkers	No	1451	91.4	1.1	128	8.6	1.1
	Yes	912	93.3	1	71	6.7	1
Depression	Yes	156	86.7	4.5	20	13.3	4.5
	No	2207	92.6	0.7	179	7.4	0.7
Hypertension	No	972	97.3	0.7	38	2.7	0.7
	Yes	1388	89	1.1	161	11	1.1
Heart problem	No	1981	94.4	0.7	125	5.6	0.7
	Yes	377	79.8	2.9	72	20.2	2.9
Diabetes	No	1657	94.5	0.7	99	5.5	0.7
	Yes	699	86.3	1.8	99	13.7	1.8
10/66 dementia	No	1913	94.9	0.7	108	5.1	0.7
	Yes	214	69.7	3.7	84	30.3	3.7

Socio-demographic and health correlates of stroke

Simple logistic regression revealed that sociodemographic features such as older age, no education, ex-smokers were associated with higher stroke prevalence (p<.05). Stroke was 2.3 times more prevalent in the 75-84 age group, and 3 times more prevalent in the above 85 years old age group as compared to the younger age group 60-74. Stroke was 3 times more prevalent in those who self-reported no education than those who have

completed tertiary education. Stroke prevalence was 2 times higher among ex-smokers than those who had never smoked. Malay ethnicity was associated with lower stroke prevalence ($p<.05$), having 0.6 times lower stroke prevalence as compared to ethnic Chinese.

Health conditions such as hypertension, heart trouble, and diabetes significantly predicted stroke prevalence ($p<.001$) at the univariate level. Stroke was more prevalent among those who self-reported having hypertension (4.5 times), heart trouble (4.2 times), diabetes (2.7 times), and dementia (8 times) as compared to those without the respective health conditions. Gender, obesity (BMI and WHR), alcohol consumption and depression were not associated with stroke prevalence in this study.

Multivariate logistic regression revealed that only hypertension, heart trouble, diabetes and 10/66 dementia were independently associated with stroke prevalence ($p<.05$). At the multivariate level, stroke prevalence was also higher among those with self-reported hypertension (4.6 times), heart trouble (2.5 times), diabetes (2.6 times), and 10/66 dementia (3.6 times) as compared to those without the respective health conditions. Ethnic differences maintained significance at the multivariate level – ethnic Malays had significantly lower (0.4 times) stroke prevalence when compared to ethnic Chinese. There was no significant difference in stroke prevalence between Indian and Chinese ethnicities.

Age group, gender, education, depression and other lifestyle (smoking, alcohol, BMI, and WHR) conditions were not associated with stroke prevalence ($p>.05$) at a multivariate level. The complete results of the socio-demographic and health correlates of stroke were presented in table 3.

Cognition, disability and care needs correlates of stroke

After adjusting for sociodemographic and health covariates in multiple linear regression analyses, stroke was negatively associated with cognitive scores ($\beta= -1.15$, $p=.0011$) and positively associated with disability scores ($\beta= 9.01$, $p<.001$). This meant that respondents with stroke were associated with greater cognitive deficits as well as greater physical disabilities.

Table 3. Sociodemographic and health correlates of stroke.

		Simple logistic regression				Multiple logistic regression			
variable	categories	OR	95% Wald Confidence Intervals (CI)		*p*	OR	95% Wald Confidence Intervals (CI)		*p*
Age group	60-74	ref				ref			
	75-84	2.38	1.54	3.69	<0.001	1.23	0.67	2.25	0.498
	85+	3.04	1.90	4.87	<0.001	0.79	0.31	2.02	0.627
Gender	Men	ref				ref			
	Women	0.91	0.61	1.37	0.657	0.73	0.37	1.42	0.347
Ethnicity	Chinese	ref				ref			
	Malay	0.63	0.41	0.96	0.030	0.41	0.20	0.82	0.012
	Indian	0.79	0.55	1.15	0.217	0.61	0.33	1.11	0.103
	Others	1.98	0.74	5.36	0.176	2.71	0.81	9.13	0.107
Education	None	2.94	1.22	7.09	0.017	1.24	0.38	4.04	0.725
	Some, but did not complete primary	1.89	0.78	4.58	0.161	1.23	0.39	3.90	0.720
	Completed primary	1.50	0.60	3.74	0.388	1.66	0.49	5.69	0.418
	Completed secondary	1.43	0.57	3.62	0.447	1.30	0.42	4.10	0.651
	Completed tertiary	ref				ref			
Smoking	Non-smoker	ref				ref			
	Ex-smoker	1.94	1.22	3.10	0.006	1.75	0.80	3.82	0.160
	Current smoker	0.92	0.42	2.03	0.830	1.15	0.44	2.98	0.774
Obesity[†]	<30 kg/m (Not obese)	ref				ref			
	≥30kg/m (Obese)	1.00	0.43	2.32	0.996	1.17	0.44	3.13	0.757
Waist-Hip-Ratio[‡]	Low	ref				ref			
	High	1.67	0.84	3.33	0.143	1.24	0.57	2.69	0.590

Table 3. Sociodemographic and health correlates of stroke (continued).

variable	categories	Simple logistic regression OR	95% Wald Confidence Intervals (CI)		*p*	Multiple logistic regression OR	95% Wald Confidence Intervals (CI)		*p*
Alcohol	No	ref				ref			
	Yes	0.77	0.51	1.15	0.201	0.56	0.30	1.06	0.076
Depression (AGECAT)	No	ref				ref			
	Yes	1.92	0.87	4.26	0.109	0.76	0.21	2.84	0.687
Hypertension	No	ref				ref			
	Yes	4.52	2.55	8.00	<0.001	4.58	1.84	11.40	0.001
Heart trouble	No	ref				ref			
	Yes	4.25	2.75	6.58	<0.001	2.45	1.30	4.63	0.006
Diabetes	No	ref				ref			
	Yes	2.72	1.80	4.12	<0.001	2.60	1.49	4.53	0.001
10/66 Dementia	No	ref				ref			
	Yes	8.06	5.19	12.52	<0.001	3.57	1.57	8.12	0.002

OR: Odds ratio; †Criteria based on WHO BMI cut-off for obesity; ‡Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

After adjusting for covariates in multinomial logistic regression analysis, stroke and care needs were found to be positively associated (p<.0001). Among older adults with stroke, there was a 4 and 10 times increase in the odds of needing care "occasionally" and "much of the time" respectively when compared to those with stroke who "did not need care". The results of the correlates of stroke with cognitive, disability scores and care needs were presented together in Table 4.

Table 4. Relationship between stroke and cognitive, WHO-DAS, and care needs scores.

Cognitive and Disability Scores	Without stroke			With stroke			B†	SE	*P*	95% CI	
	n	Mean	SE	n	Mean	SE					
Cognitive Score	2363	28.6	0.09	199	22.6	0.91	-1.15	0.45	0.011	-2.04	-0.27
Who-DAS	2363	8.70	0.36	199	37.0	3.26	9.01	2.07	<0.001	4.96	13.07
	n	%	SE	n	%	SE	OR‡	SE	*P*	95% CI	
Needs care much of the time	237	57.7	4.40	92	42.3	4.40	10.1	0.43	<0.001	4.35	23.31
Needs care occasionally	320	84.3	3.11	43	15.7	3.11	4.09	0.40	<0.001	1.86	9.01
Does not need care	1670	96.5	0.61	57	3.50	0.61	ref				

†*B* coefficient derived from multiple linear regression analysis after adjusting for sociodemographic and health covariates,
‡OR derived from multinomial logistic regression analyses after adjusting for sociodemographic and health covariates.

Discussion

Stroke prevalence

The weighted stroke prevalence found in this study was 7.6% among the older adults aged 60 and above. In an earlier population-based study that was conducted in Singapore in the year 2001 to 2003, stroke prevalence among older adults aged 65 and above was found to be 7.7%[18]. For the purpose of comparison, weighted stroke prevalence among those 65 years and above was found to be 9.3% in this study, which was higher as compared to the figures reported by the earlier study[18].

Stroke prevalence found in this study was comparable to the figures reported in Western populations, such as 8.3% in the United States among older adults 65 years and above[19]. However the figures were higher than that reported in several non-western ageing populations, such as 4.5% in Korea[20], 4.9% in Hong Kong[21], and 2.7% in Thailand[22] among older adults aged 65 years and above.

In the previous study, stroke prevalence among the three major ethnic groups (Chinese, Malay, Indian) was found to range from 3.32% to 3.75%[18]. Chinese ranked the highest in prevalence, followed by Indian and Malay ethnicities. While the ranking remained the same in this study, there was an increase in stroke prevalence

across all 3 ethnic groups, ranging from 5.1% to 7.8%. While the previous study did not find ethnic differences in stroke prevalence, the WiSE study found significant differences between the Chinese and Malay ethnicities with ethnic Malays having significantly lower stroke prevalence as compared to ethnic Chinese. These results were unexpected because according to the National Health Survey (2010), the Malay ethnicity has been associated with various stroke risk factors such as hypertension and obesity[23]. There appears to be no clear explanations for our findings, however as it was previously reported that ethnic minority groups, such as ethnic Malays, have a lower tendency of self-rating poor health [24], it is possible that either they did not want to mention being diagnosed, they were not diagnosed or did not remember being diagnosed with stroke. Since stroke prevalence data in Singapore is scarce, comparisons with past studies are insufficient, thereby making it difficult to draw sound conclusions. Future research could take into account any administrative data or registries to draw clearer outcomes on ethnic differences in stroke epidemiology.

Sociodemographic correlates of stroke

Age was significantly associated with stroke prevalence at a univariate level, a finding that was consistent with past research[18, 25]. After controlling for sociodemographic and health conditions however the association disappeared. These findings were consistent with an earlier study that examined stroke risk factors and stroke prevalence among Thai adults aged 45 to 80 years, where older age was not associated with higher stroke prevalence after all other factors were considered[22]. Unexpectedly, gender was not associated with stroke prevalence in this study and it is unclear why this is so.

Biological changes that come with old age may affect existing age/gender association with stroke risk factors, which in turn may contribute to the lack of association between age/gender and stroke prevalence. Hypertension, diabetes and cardiovascular complications usually arise with increasing age. For instance, increased high blood pressure is greatly attributed to the changes to the structure of arteries and large artery stiffness that come with age[26]. Cardiovascular problems and diabetes are usually associated with a sedentary lifestyle of old age[27, 28]. By the age of 60 to 69 years, women have a higher risk of developing hypertension due to menopause[29]. In one study, existing age/gender associations with several stroke risk factors tend to diminish or change among older age groups (70 to 80 years) and especially for men[301]. Our findings suggest that health complications that come with age and gender may have been better predictors of stroke prevalence among older adults in this study.

Health correlates of stroke

The WiSE study found that hypertension, heart trouble, and diabetes were independently associated with stroke prevalence. These findings were expected since these health conditions are established determinants of stroke [3]. Stroke was also associated with 10/66 dementia, which is also an expected finding since stroke and Alzheimer's disease have various overlapping risk characteristics[17].

Obesity was not associated with stroke prevalence. While it was not unexpected that BMI was not associated with stroke risk[31], WHR was an unexpected finding since WHR was often found to be a stronger predictor of stroke risk than BMI[32]. Our findings however were similar to the aforementioned study among Thai older adults. In both studies, BMI was not a significant predictor at a univariate level and WHR did not independently predict stroke prevalence at a multivariate level[22].

Having ever smoked (current and ex-smokers) and alcohol consumption were not associated with stroke prevalence among older adult residents. These results were unanticipated however as research has shown that these factors are dose-dependent, it could be possible that the sample of older adult respondents in this study were not heavy smokers and did not consume alcohol excessively.

Stroke prevalence was not associated with depression. Our finding differed from several other existing studies which found otherwise[5]. However, the results of this study were consistent with at least one study which found that depressive symptoms was not associated with stroke risk amongst older adults aged 65 years and above[33].

Stroke, disability and care need

As expected, stroke was found to be associated with low cognitive and high disability scores. Stroke is among the top 3 leading cause of disability among older adults aged 65 years and above in Singapore and involves long term dependency on healthcare services[34]. Despite the severity of stroke disability, a substantial number of stroke patients would not go for post-stroke therapy citing high financial costs, inconvenience, and lack of interest[35].

Our study revealed stroke to be associated with greater care needs. In Singapore, given that close to 95% of older adult residents stay with family members[36] and that age-related diseases will rise in view of the ageing population in Singapore, it is expected that there will be a substantial increase in burden and reliance on family members for their daily needs if disabled. These findings thus indicate the need to extend and improve on existing services not only to stroke survivors, but also to caregivers.

This study has some limitations, with foremost the nature of self-reported stroke which may be subjected to errors such as false reporting resulting in over or under-estimation of stroke prevalence. However, most population-based prevalence studies utilize self-report for ease of administration, cost-effectiveness and ease of direct comparison with the majority of studies which used similar methods. Third, as this is a cross-sectional study, temporal relationships between stroke and other factors cannot be established.

Conclusion

The prevalence of stroke survivors in Singapore is relatively high when compared to other Asian countries. Our findings provide support for the existing body of research on stroke prevalence and its correlates. Given that Singapore's population is ageing rapidly, our findings may indicate a need to review existing support services for stroke survivors and their caregivers. Finally, future research could investigate the role of gender, ethnicity, and lifestyle risk factors such as smoking, alcohol use and obesity on stroke prevalence to confirm the findings of this study.

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Author contributions

Author WLT wrote the first draft of the manuscript. Author EA provided statistical analysis. JAV, ES, VS, Saleha S, Shazana S, YJZ were involved in data collection and literature review searches. Author MS and SAC wrote the protocol and designed the study. LLN provided intellectual input in the area of data collection and analyses. All authors contributed to and have approved the final manuscript.

Data Sharing

Data are not available for online access; however, readers who wish to gain access to the data can write to the senior author (MS) at mythily@imh.com.sg with their requests. Access can be granted and subjected to the Institutional Review Board (IRB) and the research collaborative agreement guidelines. This is a requirement mandated for this research study by our IRB and funders.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 to 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	5
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6,7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	6 to 12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10,11
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	4,5,6
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	12 to 15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of stroke, risk factors, disability, and care needs in older adults in Singapore: Results from the WiSE study

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Keywords:	stroke prevalence, stroke risk factors, Epidemiology < TROPICAL MEDICINE, south-east Asia, multi-ethnic

Title page

Prevalence of stroke, risk factors, disability, and care needs in older adults in Singapore: Results from the WiSE study

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Abstract

Objectives: The aims of the present study were to establish the prevalence of stroke, and to explore the association between stroke prevalence and socio-demographic, health factors, disability, cognitive functioning, and care needs among older adult residents in Singapore.

Setting: Data was drawn from the Well-being of the Singapore Elderly (WiSE) study - a cross-sectional epidemiological survey conducted from 2012 to 2013 on older adults living in Singapore.

Participants Singapore residents (Citizens and permanent residents) 60 years and above who were living in Singapore at that point of time. Older adult residents who were institutionalized were also included in this study. Those who were not living in Singapore or who were not contactable were excluded from the study. A total population sample of 2562 participants completed the survey. The response rate was 65.6% (2565/3913). Participants comprised 43.6% males and 56.4% females. The sample comprised 39.4% Chinese, 29.1% Malay, 30.1% Indian, and other ethnicities 1.4%.

Primary and secondary outcome measures: Stroke, along with other health and mental health conditions, disability and cognitive functioning, were determined by self-report.

Results: Weighted stroke prevalence was 7.6% among older adults aged 60 and above. At a multivariate level, Malay ethnicity (OR=0.41 p=0.012) , hypertension (OR=4.58, p=0.001), heart trouble (OR=2.45, p=0.006), diabetes (OR=2.60, p=0.001) and dementia (OR=3.57, p=0.002) were associated with stroke prevalence.

Conclusions: Several findings of this study were consistent with previous reports. Given that Singapore's population is ageing rapidly, our findings may indicate the need to review existing support services for stroke survivors and their caregivers. Future research could investigate the association between various sociodemographic and health conditions and stroke prevalence to confirm some of the findings of this study.

Keywords: stroke prevalence, stroke risk factors, epidemiology, south-east Asia, multi-ethnic

Article Summary

Strengths and limitations

- This study was based on a large nation-wide population sample of 2562 older adult participants.
- An extensive list of socio-demographic and health factors of stroke were accounted for during multivariate regression analyses.
- Older adults who were institutionalized were represented in this study.
- This study examined self-reported stroke which may be subjected to errors such as false reporting resulting in over or under-estimation of stroke prevalence. As this is a cross-sectional study, temporal relationships between stroke and other factors cannot be established.

Background

Stroke is defined as "a neurological deficit attributed to an acute focal injury of the central nervous system (CNS) by a vascular cause".[1] Older age and the male gender are associated with greater stroke risk.[2] Health conditions such as hypertension, cardiovascular diseases, and diabetes are established risk factors of stroke;[3] whereas lifestyle factors such as smoking, alcohol consumption and obesity are found to contribute to stroke risk, some of which are dose-dependent.[4] Depression and dementia have also found to be associated with stroke.[5, 6]

Stroke is one of the leading causes of disability and disease burden worldwide.[7] Despite the global severity of stroke, stroke prevalence estimates outside Western, South Asian or East Asian regions are less readily available.[8, 9] Establishing stroke prevalence estimates are important in providing feedback and planning of stroke rehabilitation and prevention, and stroke data from Asian regions provide a basis for comparison against Western estimates and trends.[10] Recent stroke estimates from multi-racial Asian populations such as those in South-east Asia are also lacking. Thus, more data is needed to ascertain stroke prevalence in Asian populations with diverse ethnic communities.

Singapore has a resident population of 3.93 million.[11] The population comprises 74.3% Chinese, 13.4% Malay, 9.1% Indian and 3.2% other ethnicities. Singapore's population is ageing mainly due to an increase in the life expectancy - 82.7 years in 2015 from 65.8 years in 1970.[12] Singapore's older adult residents (defined as Singapore citizens and permanent residents aged 65 and above) constitute 12.4% of the resident population, which is an increase from 7.2% in the year 2000.[11, 13] The prevalence of chronic diseases including stroke is expected to be higher among this ageing population. Despite its growing importance and relevance, there exists a paucity of research on stroke prevalence in Singapore. To our knowledge, only one study (2005) was found to have reported stroke prevalence. In that study, stroke prevalence was found to be 7.67% among adults aged 65 years and above. However, since the data was collected in 2001 to 2003, it is unclear at this current juncture of at least a decade later, how stroke prevalence has changed in Singapore. Newer estimates can help to provide a more relevant, up-to-date understanding of stroke prevalence in a multi-ethnic Singapore, which can be useful in substantiating timely feedback for local public health policies and also provide a basis of relevant comparison against western estimates and trends.

The aims of the current study were: 1) to establish the prevalence of stroke among adults aged 60 years and above in Singapore, 2) to explore the correlation of stroke with socio-demographic factors and health conditions, and 3) to explore the association of stroke with disability, cognitive functioning, and care needs.

Methods

This study used data from the Well-being of the Singapore Elderly (WiSE) study which was conducted from October 2012 to December 2013. The WiSE study was approved by the institutional ethics review boards: National Healthcare Group Domain Specific Review Board and the SingHealth Centralised Institutional Review Board. Participants provided written consent to participate in this study.

The overall sample comprised of older adult Singapore residents (Singapore citizens and permanent residents) aged 60 years and above, who were living in Singapore at that point of time. Older adult residents who were institutionalized were also included in this study. Those who were not living in Singapore or who were not contactable were excluded from the study.

Sampling was conducted at random using a disproportionate stratified sampling design where the Malays and Indians, and those aged 75 and above were oversampled so as to increase precision of subgroup estimation. To ensure that the results of the WiSE study are generalizable to the older adult population in Singapore, the results were weighted against the older adult resident population of 2011 (table 1).

All participants who consented to the study were administered a series of questionnaires which comprised questions on socio-demographics, health, cognition, and neurological tests in a single assessment. For each participant, an informant was also chosen and administered informant-adapted questionnaires. An informant was defined as the "person who knows the older person best". Some informants were caregivers whilst others were in close contact with the older person without a caregiving role. The face-to-face assessments were carried out based on the participants' and informants' preferred language or dialect and these interviews were conducted by trained interviewers. Participants completed the questionnaires without influence of their informants even in cases when participants had cognitive deficits. The questionnaires were valid, reliable and made culturally relevant for the older adults in Singapore. An earlier article[14] provides further details of the study.

The main questionnaires relevant to this current analysis were:

Socio-demographic questionnaire: Participants were asked to provide socio-demographic information such as their age, education level, and height and weight measurements.

Stroke and health conditions: Participants were asked if they had ever been told by a doctor that they had stroke. Participants were questioned in the same way for other health conditions such as hypertension, heart trouble, and diabetes. Additionally, they were asked to provide more details about who diagnosed their health condition and whether they were still seeking treatment for the condition.

Smoking: Participants provided a response for the following question, "Has there ever been a period when you smoked cigarettes, cigars, or a pipe, chewing tobacco, beedi (Indian cigarette) or snuff nearly every day?", responses were binary 0 (No) and 1 (Yes) and, "Do you still use tobacco regularly?", responses were binary 0 (No) and 1 (Yes). Responses for the 2 questions were then categorized into 0 (Non-smoker), 1 (Ex-smoker) and 2 (Current smoker).

Alcohol use: Participants provided responses for the following question, "Was there ever a period in your life when you drank at least 12 drinks in a year?" Responses were 0 (Never drank alcoholic drinks), 1 (No, less than 12 drinks in a year), 2 (Yes, more than 12 drinks a year). Responses were recoded as 0 (Never drank alcoholic drinks), original responses 1 and 2 were recoded as 1 (Yes, ever drank alcoholic drinks).

Body Mass Index (BMI) and Waist-Hip-Ratio (WHR): Body mass index was calculated by the division of weight with height. Those with BMI $\geq 30 kg/m^2$ were considered obese[15]. Waist-hip-ratio is a measurement of abdominal obesity, measured by a ratio of waist to hip circumference. Males with waist-hip-ratio greater than 0.90 and females greater than 0.80, were considered to be obese[15].

Geriatric Mental State-Automated Geriatric Examination for Computer Assisted Taxonomy (GMS-AGECAT, Depression): A diagnostic assessment for depression as well as other mental illnesses that uses a computerized algorithm (AGECAT) to make diagnoses. 5 levels of severity are generated from 0 (none) to 5 (severe). A severity level 0 would indicate no depression; levels 1-3 indicate subsyndromal depression, levels 4-5 indicate DSM-IV depression. For the purpose of this analysis, responses were recoded as binary responses 0 (levels 1-3), 1 (levels 4 and 5). Inter-rater agreement on depression diagnoses between AGECAT and psychiatrists' achieved a kappa value of 0.88[16].

A cognitive test battery comprising two cognitive tests, a) the community screening instrument for dementia (CSI'D) which incorporated the animal naming verbal fluency task by the Consortium to Establish a

Registry for Alzheimer's Dementia (CERAD), and b) a 10 word-list learning task with delayed recall by CERAD (modified). An aggregated score (COGSCORE) was generated by taking the summation of all item-weighted scores of the entire cognitive test battery.

10/66 Dementia: A 10/66 dementia diagnosis was given to older adults based on a cut-off determined by logistic regression coefficients of CSI'D COGSCORE, RELSCORE (unweighted total informant score of functional and cognitive decline in the older adult), GMS/AGECAT, and the modified CERAD. A cut-off of more than 0.25 was used as it produced the best sensitivity and specificity to identify dementia cases.[17] Validation of the 10/66 diagnosis revealed that it had a substantial agreement with clinician diagnosis in the WiSE study.[14]

World Health Organisation-Disability Assessment Schedule (WHO-DAS) 2.0: It is a 12-item questionnaire which assesses 6 domains of functioning in cognition, mobility, self-care, getting along, life activities and participation (WHODAS). Item responses range from 0 (no difficulty) to 4 (extremely difficulty or cannot do). A total WHO-DAS score is calculated by the summation of the domain scores.

Care need: defined as the amount of care needed by the older person that is provided by the informant. Informants were asked to respond to whether: the older person needs care much of the time (1), needs care occasionally (2), does not need care; they are able to do everything for themselves (3).

Statistical Analysis

Statistical analyses were carried out using the SAS System version 9.3. All of the statistical analyses used in this study were based on weighted data. First, simple logistic regression was used to analyze the correlates of stroke prevalence at a univariate level. Second, multiple logistic regression was used to analyze socio-demographic and health correlates of stroke at a multivariate level. Socio-demographic factors such as age group, gender, ethnicity, education and health or lifestyle conditions such as hypertension, heart trouble, diabetes, smoking, alcohol use, depression and dementia were used as predictors in both regression analyses. Associations with cognitive and disability scores were estimated using multiple linear regressions, while association with care needs was estimated using multinomial logistic regression after accounting for covariates. Statistical significance was set at a conventional cut-off point at $P<.05$, two-tailed.

Results

The characteristics of the sample population were summarized in table 1. In all, 2562 participants were included in the current analysis. Overall response rate was 65.6% (2565/3913). The mean age was approximately 70 years old (M=69.9, SD=7.85). Participants comprised 43.6% males and 56.4% females. The sample comprised 39.4% Chinese, 29.1% Malay, 30.1% Indian, and other ethnicities 1.4%.

Table 1: Descriptive characteristics of the sample population.

						Singapore's general population 2011	
Variable	Category	n	Unweighted %	Weighted %	SE	N (000)	%
Age group	60-74	1493	58.3	75.1	0.02	420.5	75.0
	75-84	668	26.1	19.4	0.02	109.1	19.5
	85+	401	15.7	5.5	0.01	31.0	5.5
Gender	Men	1116	43.6	44.1	1.41	258.9	46.2
	Women	1446	56.4	55.9	1.41	301.7	53.8
Ethnicity	Chinese	1009	39.4	83.3	0.03	467.0	83.3
	Malay	745	29.1	9.3	0.01	52.00	9.3
	Indian	772	30.1	6.0	0.02	33.50	6.0
	Others	36	1.4	1.4	0.01	8.10	1.4
Education	None	510		16.4	0.98		
	Some, but did not complete primary	620		24.0	1.21		
	Completed primary	639		24.8	1.23		
	Completed secondary	517		22.4	1.20		
	Completed tertiary	262		12.4	0.97		
Smoking	No	1888		74.5	1.21		
	Ex-smoker	438		15.9	0.99		
	Current smoker	236		9.5	0.83		
Body-Mass-Index (BMI) †	<30 kg/m^2 (Not obese)	1969		91.4	0.75		
	≥30kg/m^2 (Obese)	318		8.6	0.75		
Waist hip ratio (WHR) ‡	Low	401		20.2	1.20		
	High	1924		79.8	1.20		
Drinkers	No	1579		48.2	1.40		
	Yes	983		51.8	1.40		
GMS Depression	Yes	176		3.7	0.45		
	No	2386		96.3	0.45		
Hypertension	No	1010		40.6	1.39		
	Yes	1549		59.4	1.39		
Heart problem	No	2106		86.7	0.90		

	Yes	449			13.3	0.90	
Diabetes	No	1756			74.5	1.21	
	Yes	798			25.5	1.21	
10/66 dementia	No	2021			90.0	0.70	
	Yes	398			10.0	0.70	

†Criteria based on WHO BMI cut-off for obesity; ‡Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

Out of 2562 older adult participants, 199 respondents reported that they had ever been told by a doctor to have had stroke. Missing answers were deleted listwise. The overall weighted stroke prevalence was 7.6%, 95%CI[6.2,9.0] among older adult residents aged 60 years and above. Weighted stroke prevalence for those aged 65 years and above was 9.3%. A detailed breakdown of the prevalence of stroke by socio-demographic and health variables were presented in table 2.

Table 2. Number of stroke and non-stroke cases by sociodemographic and health factors.

		Without stroke			Stroke		
Variable	Category	n	%	SE	n	%	SE
Age group	60-74	1415	94.3	0.8	78	5.7	0.8
	75-84	599	87.4	1.8	69	12.6	1.8
	85+	349	84.5	2.4	52	15.5	2.4
Gender	Men	1033	92	1.1	83	8	1.1
	Women	1330	92.7	0.9	116	7.3	0.9
Ethnicity	Chinese	913	92.2	0.8	96	7.8	0.8
	Malay	704	94.9	0.9	41	5.1	0.9
	Indian	715	93.7	0.9	57	6.3	0.9
	Others	31	85.6	6.1	5	14.4	6.1
Education	None	455	87.8	2.1	55	12.2	2.1
	Some, but did not complete primary	566	91.8	1.5	54	8.2	1.5
	Completed primary	596	93.4	1.4	43	6.6	1.4
	Completed secondary	485	93.7	1.4	32	6.3	1.4
	Completed tertiary	249	95.5	1.7	13	4.5	1.7
Smoking	No	1749	93.2	0.8	139	6.8	0.8
	Ex-smoker	393	87.7	2.2	45	12.3	2.2
	Current smoker	221	93.8	2.2	15	6.2	2.2
BMI†	<30 kg/m^2 (Not obese)	1850	94.1	0.7	119	5.9	0.7
	≥30kg/m^2 (Obese)	304	94.1	2.3	14	5.9	2.3
WHR‡	Low	382	96	1.2	19	4	1.2
	High	1809	93.5	0.8	115	6.5	0.8
Drinkers	No	1451	91.4	1.1	128	8.6	1.1
	Yes	912	93.3	1	71	6.7	1
Depression	Yes	156	86.7	4.5	20	13.3	4.5
	No	2207	92.6	0.7	179	7.4	0.7

Table 2 (cont'd).							
Hypertension	No	972	97.3	0.7	38	2.7	0.7
	Yes	1388	89	1.1	161	11	1.1
Heart problem	No	1981	94.4	0.7	125	5.6	0.7
	Yes	377	79.8	2.9	72	20.2	2.9
Diabetes	No	1657	94.5	0.7	99	5.5	0.7
	Yes	699	86.3	1.8	99	13.7	1.8
10/66 dementia	No	1913	94.9	0.7	108	5.1	0.7
	Yes	214	69.7	3.7	84	30.3	3.7

†Criteria based on WHO BMI cut-off for obesity; ‡Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

Socio-demographic and health correlates of stroke

Simple logistic regression revealed that sociodemographic features such as older age, no education, ex-smokers were associated with higher stroke prevalence ($p<.05$). Stroke was 2.3 times more prevalent in the 75-84 age group, and 3 times more prevalent in the above 85 years old age group as compared to the younger age group 60-74. Stroke was 3 times more prevalent in those who self-reported no education than those who have completed tertiary education. Stroke prevalence was 2 times higher among ex-smokers than those who had never smoked. Malay ethnicity was associated with lower stroke prevalence ($p<.05$), having 0.6 times lower stroke prevalence as compared to ethnic Chinese.

Health conditions such as hypertension, heart trouble, and diabetes significantly predicted stroke prevalence ($p<.001$) at the univariate level. Stroke was more prevalent among those who self-reported having hypertension (4.5 times), heart trouble (4.2 times), diabetes (2.7 times), and dementia (8 times) as compared to those without the respective health conditions. Gender, obesity (BMI and WHR), alcohol consumption and depression were not associated with stroke prevalence in this study.

Multivariate logistic regression revealed that only hypertension, heart trouble, diabetes and 10/66 dementia were independently associated with stroke prevalence ($p<.05$). At the multivariate level, stroke prevalence was also higher among those with self-reported hypertension (4.6 times), heart trouble (2.5 times), diabetes (2.6 times), and 10/66 dementia (3.6 times) as compared to those without the respective health conditions. Ethnic differences maintained significance at the multivariate level – ethnic Malays had significantly lower (0.4 times) stroke prevalence when compared to ethnic Chinese. There was no significant difference in stroke prevalence between Indian and Chinese ethnicities.

Age group, gender, education, depression and other lifestyle (smoking, alcohol, BMI, and WHR) conditions were not associated with stroke prevalence (p>.05) at a multivariate level. The complete results of the socio-demographic and health correlates of stroke were presented in table 3.

Cognition, disability and care needs correlates of stroke

After adjusting for sociodemographic and health covariates in multiple linear regression analyses, stroke was negatively associated with cognitive scores (β= -1.15, p=.0011) and positively associated with disability scores (β= 9.01, p<.001). This meant that respondents with stroke were associated with greater cognitive deficits as well as greater physical disabilities.

Table 3. Sociodemographic and health correlates of stroke.

		Simple logistic regression				Multiple logistic regression			
variable	categories	OR	95% Wald Confidence Intervals (CI)		*p*	OR	95% Wald Confidence Intervals (CI)		*p*
Age group	60-74	ref				ref			
	75-84	2.38	1.54	3.69	<0.001	1.23	0.67	2.25	0.498
	85+	3.04	1.90	4.87	<0.001	0.79	0.31	2.02	0.627
Gender	Men	ref				ref			
	Women	0.91	0.61	1.37	0.657	0.73	0.37	1.42	0.347
Ethnicity	Chinese	ref				ref			
	Malay	0.63	0.41	0.96	0.030	0.41	0.20	0.82	0.012
	Indian	0.79	0.55	1.15	0.217	0.61	0.33	1.11	0.103
	Others	1.98	0.74	5.36	0.176	2.71	0.81	9.13	0.107
Education	None	2.94	1.22	7.09	0.017	1.24	0.38	4.04	0.725
	Some, but did not complete primary	1.89	0.78	4.58	0.161	1.23	0.39	3.90	0.720
	Completed primary	1.50	0.60	3.74	0.388	1.66	0.49	5.69	0.418
	Completed secondary	1.43	0.57	3.62	0.447	1.30	0.42	4.10	0.651
	Completed tertiary	ref				ref			
Smoking	Non-smoker	ref				ref			
	Ex-smoker	1.94	1.22	3.10	0.006	1.75	0.80	3.82	0.160
	Current smoker	0.92	0.42	2.03	0.830	1.15	0.44	2.98	0.774
Obesity[†]	<30 kg/m^2 (Not obese)	ref				ref			
	≥30kg/m^2 (Obese)	1.00	0.43	2.32	0.996	1.17	0.44	3.13	0.757
Waist-Hip-Ratio[‡]	Low	ref				ref			
	High	1.67	0.84	3.33	0.143	1.24	0.57	2.69	0.590

Table 3. Sociodemographic and health correlates of stroke (continued).

variable	categories	Simple logistic regression OR	95% Wald Confidence Intervals (CI)		*p*	Multiple logistic regression OR	95% Wald Confidence Intervals (CI)		*p*
Alcohol	No	ref				ref			
	Yes	0.77	0.51	1.15	0.201	0.56	0.30	1.06	0.076
Depression (AGECAT)	No	ref				ref			
	Yes	1.92	0.87	4.26	0.109	0.76	0.21	2.84	0.687
Hypertension	No	ref				ref			
	Yes	4.52	2.55	8.00	<0.001	4.58	1.84	11.40	0.001
Heart trouble	No	ref				ref			
	Yes	4.25	2.75	6.58	<0.001	2.45	1.30	4.63	0.006
Diabetes	No	ref				ref			
	Yes	2.72	1.80	4.12	<0.001	2.60	1.49	4.53	0.001
10/66 Dementia	No	ref				ref			
	Yes	8.06	5.19	12.52	<0.001	3.57	1.57	8.12	0.002

OR: Odds ratio; [†]Criteria based on WHO BMI cut-off for obesity; [‡]Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

After adjusting for covariates in multinomial logistic regression analysis, stroke and care needs were found to be positively associated (p<.0001). Among older adults with stroke, there was a 4 and 10 times increase in the odds of needing care "occasionally" and "much of the time" respectively when compared to those with stroke who "did not need care". The results of the correlates of stroke with cognitive, disability scores and care needs were presented together in Table 4.

Table 4. Relationship between stroke and cognitive, WHO-DAS, and care needs scores.

Cognitive and Disability Scores	Without stroke			With stroke			B†	SE	*P*	95% CI	
	n	Mean	SE	n	Mean	SE					
Cognitive Score	2363	28.6	0.09	199	22.6	0.91	-1.15	0.45	0.011	-2.04	-0.27
Who-DAS	2363	8.70	0.36	199	37.0	3.26	9.01	2.07	<0.001	4.96	13.07
	n	%	SE	n	%	SE	OR‡	SE	*P*	95% CI	
Needs care much of the time	237	57.7	4.40	92	42.3	4.40	10.1	0.43	<0.001	4.35	23.31
Needs care occasionally	320	84.3	3.11	43	15.7	3.11	4.09	0.40	<0.001	1.86	9.01
Does not need care	1670	96.5	0.61	57	3.50	0.61	ref				

†*B* coefficient derived from multiple linear regression analysis after adjusting for sociodemographic and health covariates,
‡OR derived from multinomial logistic regression analyses after adjusting for sociodemographic and health covariates.

Discussion

Stroke prevalence

The weighted stroke prevalence found in this study was 7.6% among the older adults aged 60 and above. In an earlier population-based study that was conducted in Singapore in the year 2001 to 2003, stroke prevalence among older adults aged 65 and above was found to be 7.7%.[18] For the purpose of comparison, weighted stroke prevalence among those 65 years and above was found to be 9.3% in this study, which was higher as compared to the figures reported by the earlier study.[18]

Stroke prevalence found in this study was comparable to the figures reported in Western populations, such as 8.3% in the United States among older adults 65 years and above.[19] However the figures were higher than that reported in several non-western ageing populations, such as 4.5% in Korea[20], 4.9% in Hong Kong[21], and 2.7% in Thailand[22] among older adults aged 65 years and above.

In the previous study, stroke prevalence among the three major ethnic groups (Chinese, Malay, Indian) was found to range from 3.32% to 3.75%.[18] Chinese ranked the highest in prevalence, followed by Indian and Malay ethnicities. While the ranking remained the same in this study, there was an increase in stroke prevalence

across all 3 ethnic groups, ranging from 5.1% to 7.8%. While the previous study did not find ethnic differences in stroke prevalence, the WiSE study found significant differences between the Chinese and Malay ethnicities with ethnic Malays having significantly lower stroke prevalence as compared to ethnic Chinese. These results were unexpected because according a recent the National Health Survey (2010), the Malay ethnicity has been associated with various stroke risk factors such as hypertension and obesity.[23] There appears to be no clear explanations for our findings, however as it was previously reported that ethnic minority groups, such as ethnic Malays, have a lower tendency of self-rating poor health,[24] it is possible that either they did not want to mention being diagnosed, they were not diagnosed or did not remember being diagnosed with stroke. Additionally, according to the Singapore's census population statistics (2010), it has been reported that those belonging to the Malay ethnic group have the lowest median household income.[25] Thus it could be possible that they have fewer opportunities to be informed about their health, which could also explain the lower self-reported stroke. As stroke prevalence data in Singapore is scarce, comparisons with past studies are insufficient, thereby making it difficult to draw sound conclusions. Future research could take into account any administrative data or registries to draw clearer outcomes on ethnic differences in stroke epidemiology.

Sociodemographic correlates of stroke

Age was significantly associated with stroke prevalence at a univariate level, a finding that was consistent with past research.[18, 26] After controlling for sociodemographic and health conditions however the association disappeared. These findings were consistent with an earlier study that examined stroke risk factors and stroke prevalence among Thai adults aged 45 to 80 years, where older age was not associated with higher stroke prevalence after all other factors were considered.[22] Unexpectedly, gender was not associated with stroke prevalence in this study and it is unclear why this is so.

Biological changes that come with old age may affect existing age/gender association with stroke risk factors, which in turn may contribute to the lack of association between age/gender and stroke prevalence. Hypertension, diabetes and cardiovascular complications usually arise with increasing age. For instance, increased high blood pressure is greatly attributed to the changes to the cardiovascular system, structure of arteries and large artery stiffness that come with age.[27, 28] Cardiovascular problems and diabetes are usually associated with a sedentary lifestyle of old age.[29,30] By the age of 60 to 69 years, women have a higher risk of developing hypertension due to menopause.[31] However, research has also shown that certain health conditions become less prevalent with increasing age. In one study, existing age/gender associations with

several stroke risk factors tend to diminish or change among older age groups (70 to 80 years) and especially for men.[32] Our findings suggest that health complications that come with age and gender may have been better predictors of stroke prevalence among older adults in this study.

Health correlates of stroke

The WiSE study found that hypertension, heart trouble, and diabetes were independently associated with stroke prevalence. These findings were expected since these health conditions are established determinants of stroke [3]. Stroke was also associated with 10/66 dementia, which is also an expected finding since stroke and Alzheimer's disease have various overlapping risk characteristics.[17, 33]

Obesity was not associated with stroke prevalence. While it was not unexpected that there was no association between BMI and stroke risk, WHR was an unexpected finding since WHR was found to be a stronger predictor of stroke risk than BMI.[34,35] Our findings however were similar to the aforementioned study among Thai older adults. In both studies, BMI was not a significant predictor at a univariate level and WHR did not independently predict stroke prevalence at a multivariate level.[22] Having ever smoked (current and ex-smokers) and alcohol consumption were not associated with stroke prevalence among older adult residents. These results were unanticipated however as research has shown that these factors are dose-dependent,[36, 37, 38, 39] it could be possible that the sample of older adult respondents in this study were not heavy smokers and did not consume alcohol excessively.

Stroke prevalence was not associated with depression in this study. Our finding differed from several other existing studies and meta-analyses which found otherwise.[5,40] Although meta-analyses have shown a positive association, majority of the studies included in these meta-analyses did not take into adequate account of stroke risk factors such as BMI or alcohol use.[41] The results of this study were consistent with at least one prospective study which found that depression was not associated with stroke risk amongst older adults, after adequately controlling for covariates.[42,43] Taken together, depression did not appear to be a relevant risk factor of stroke in older adults.

Stroke, disability and care need

As expected, stroke was found to be associated with low cognitive and high disability scores. Stroke is among the top 3 leading cause of disability among older adults aged 65 years and above in Singapore and involves long term dependency on healthcare services.[44] Despite the severity of stroke disability, a substantial

number of stroke patients would not go for post-stroke therapy citing high financial costs, inconvenience, and lack of interest.[45]

Our study revealed stroke to be associated with greater care needs. In Singapore, given that close to 95% of older adult residents stay with family members[46] and that age-related diseases will rise in view of the ageing population in Singapore, it is expected that there will be a substantial increase in burden and reliance on family members for their daily needs if disabled. These findings thus indicate the need to extend and improve on existing services not only to stroke survivors, but also to caregivers.

This study has some limitations, with foremost the nature of self-reported stroke which may be subjected to errors such as false reporting resulting in over or under-estimation of stroke prevalence. However, most population-based prevalence studies utilize self-report for ease of administration, cost-effectiveness and ease of direct comparison with the majority of studies which used similar methods. Third, as this is a cross-sectional study, temporal relationships between stroke and other factors cannot be established.

Future research should take into consideration the importance of establishing stroke incidence to provide a well-informed understanding of stroke epidemiology in Singapore. Published research articles on stroke incidence in Singapore are rare- the most recent study was published in the year 2000.[47] In Adelaide, possibly owing to advances in healthcare intervention and public initiatives, stroke incidence rates have declined despite an ageing population.[48,49] At the present juncture it remains unclear whether recent incidence estimates of stroke have increased or decreased relative to past data and worldwide in Singapore.

Conclusion

The prevalence of stroke survivors in Singapore is relatively high when compared to other Asian countries. Our findings provide support for the existing body of research on stroke prevalence and its correlates. Given that Singapore's population is ageing rapidly, our findings may indicate a need to review existing support services for stroke survivors and their caregivers. Finally, future research could take into consideration incidence rates to present a more relevant understanding of stroke epidemiology in Singapore, and also investigate the role of gender, ethnicity, and lifestyle risk factors such as smoking, alcohol use and obesity on stroke prevalence to confirm the findings of this study.

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Author contributions

Author WLT wrote the first draft of the manuscript. Author EA provided statistical analysis. JAV, ES, VS, Saleha S, Shazana S, YJZ were involved in data collection and literature review searches. Author MS and SAC wrote the protocol and designed the study. LLN provided intellectual input in the area of data collection and analyses. All authors contributed to and have approved the final manuscript.

Data Sharing

Data are not available for online access; however, readers who wish to gain access to the data can write to the senior author (MS) at mythily@imh.com.sg with their requests. Access can be granted and subjected to the Institutional Review Board (IRB) and the research collaborative agreement guidelines. This is a requirement mandated for this research study by our IRB and funders.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 to 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	5
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6,7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	6 to 12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10,11
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	4,5,6
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	12 to 15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of stroke, risk factors, disability, and care needs in older adults in Singapore: Results from the WiSE study

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Title page

Prevalence of stroke, risk factors, disability, and care needs in older adults in Singapore: Results from the WiSE study

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Abstract

Objectives: The aims of the present study were to establish the prevalence of stroke, and to explore the association between stroke prevalence and socio-demographic, health factors, disability, cognitive functioning, and care needs among older adult residents in Singapore.

Setting: Data was drawn from the Well-being of the Singapore Elderly (WiSE) study - a cross-sectional epidemiological survey conducted from 2012 to 2013 on older adults living in Singapore.

Participants Singapore residents (Citizens and permanent residents) 60 years and above who were living in Singapore at that point of time. Older adult residents who were institutionalized were also included in this study. Those who were not living in Singapore or who were not contactable were excluded from the study. A total population sample of 2562 participants completed the survey. The response rate was 65.6% (2565/3913). Participants comprised 43.6% males and 56.4% females. The sample comprised 39.4% Chinese, 29.1% Malay, 30.1% Indian, and other ethnicities 1.4%.

Primary and secondary outcome measures: Stroke, along with other health and mental health conditions, disability and cognitive functioning, were determined by self-report.

Results: Weighted stroke prevalence was 7.6% among older adults aged 60 and above. At a multivariate level, Malay ethnicity (OR=0.41 *p*=0.012, 95%CI[0.20, 0.82]) , hypertension (OR=4.58, *p*=0.001, 95%CI[1.84, 11.40]), heart trouble (OR=2.45, *p*=0.006, 95%CI[1.30, 4.63]), diabetes (OR=2.60, *p*=0.001, 95%CI[1.49, 4.53]) and dementia (OR=3.57, *p*=0.002, 95%CI[1.57, 8.12]) were associated with stroke prevalence.

Conclusions: Several findings of this study were consistent with previous reports. Given that Singapore's population is ageing rapidly, our findings may indicate the need to review existing support services for stroke survivors and their caregivers. Future research could investigate the association between various sociodemographic and health conditions and stroke prevalence to confirm some of the findings of this study.

Keywords: stroke prevalence, stroke risk factors, epidemiology, south-east Asia, multi-ethnic

Article Summary

Strengths and limitations

- This study was based on a large nation-wide population sample of 2562 older adult participants.
- An extensive list of socio-demographic and health factors of stroke were accounted for during multivariate regression analyses.
- Older adults who were institutionalized were represented in this study.
- This study examined self-reported stroke which may be subjected to errors such as false reporting resulting in over or under-estimation of stroke prevalence. As this is a cross-sectional study, temporal relationships between stroke and other factors cannot be established.

Background

Stroke is defined as "a neurological deficit attributed to an acute focal injury of the central nervous system (CNS) by a vascular cause".[1] Older age and the male gender are associated with greater stroke risk.[2] Health conditions such as hypertension, cardiovascular diseases, and diabetes are established risk factors of stroke;[3] whereas lifestyle factors such as smoking, alcohol consumption and obesity are found to contribute to stroke risk, some of which are dose-dependent.[4] Depression and dementia have also found to be associated with stroke.[5, 6]

Stroke is one of the leading causes of disability and disease burden worldwide.[7] Despite the global severity of stroke, stroke prevalence estimates outside Western, South Asian or East Asian regions are less readily available.[8, 9] Establishing stroke prevalence estimates are important in providing feedback and planning of stroke rehabilitation and prevention, and stroke data from Asian regions provide a basis for comparison against Western estimates and trends.[10] Recent stroke estimates from multi-racial Asian populations such as those in South-east Asia are also lacking. Thus, more data is needed to ascertain stroke prevalence in Asian populations with diverse ethnic communities.

Singapore has a resident population of 3.93 million.[11] The population comprises 74.3% Chinese, 13.4% Malay, 9.1% Indian and 3.2% other ethnicities. Singapore's population is ageing mainly due to an increase in the life expectancy - 82.7 years in 2015 from 65.8 years in 1970.[12] Singapore's older adult residents (defined as Singapore citizens and permanent residents aged 65 and above) constitute 12.4% of the resident population, which is an increase from 7.2% in the year 2000.[11, 13] The prevalence of chronic diseases including stroke is expected to be higher among this ageing population. Despite its growing importance and relevance, there exists a paucity of research on stroke prevalence in Singapore. To our knowledge, only one study (2005) was found to have reported stroke prevalence. In that study, stroke prevalence was found to be 7.67% among adults aged 65 years and above. However, since the data was collected in 2001 to 2003, it is unclear at this current juncture of at least a decade later, how stroke prevalence has changed in Singapore. Newer estimates can help to provide a more relevant, up-to-date understanding of stroke prevalence in a multi-ethnic Singapore, which can be useful in substantiating timely feedback for local public health policies and also provide a basis of relevant comparison against western estimates and trends.

The aims of the current study were: 1) to establish the prevalence of stroke among adults aged 60 years and above in Singapore, 2) to explore the correlation of stroke with socio-demographic factors and health conditions, and 3) to explore the association of stroke with disability, cognitive functioning, and care needs.

Methods

This study used data from the Well-being of the Singapore Elderly (WiSE) study which was conducted from October 2012 to December 2013. The WiSE study was approved by the institutional ethics review boards: National Healthcare Group Domain Specific Review Board and the SingHealth Centralised Institutional Review Board. Participants provided written consent to participate in this study.

The overall sample comprised of older adult Singapore residents (Singapore citizens and permanent residents) aged 60 years and above, who were living in Singapore at that point of time. Older adult residents who were institutionalized were also included in this study. Those who were not living in Singapore or who were not contactable were excluded from the study.

Sampling was conducted at random using a disproportionate stratified sampling design where the Malays and Indians, and those aged 75 and above were oversampled so as to increase precision of subgroup estimation. To ensure that the results of the WiSE study are generalizable to the older adult population in Singapore, the results were weighted against the older adult resident population of 2011 (table 1).

All participants who consented to the study were administered a series of questionnaires which comprised questions on socio-demographics, health, cognition, and neurological tests in a single assessment. For each participant, an informant was also chosen and administered informant-adapted questionnaires. An informant was defined as the "person who knows the older person best". Some informants were caregivers whilst others were in close contact with the older person without a caregiving role. The face-to-face assessments were carried out based on the participants' and informants' preferred language or dialect and these interviews were conducted by trained interviewers. Participants completed the questionnaires without influence of their informants even in cases when participants had cognitive deficits. The questionnaires were valid, reliable and made culturally relevant for the older adults in Singapore. An earlier article[14] provides further details of the study.

The main questionnaires relevant to this current analysis were:

Socio-demographic questionnaire: Participants were asked to provide socio-demographic information such as their age, education level, and height and weight measurements.

Stroke and health conditions: Participants were asked if they had ever been told by a doctor that they had stroke. Participants were questioned in the same way for other health conditions such as hypertension, heart trouble, and diabetes. Additionally, they were asked to provide more details about who diagnosed their health condition and whether they were still seeking treatment for the condition.

Smoking: Participants provided a response for the following question, "Has there ever been a period when you smoked cigarettes, cigars, or a pipe, chewing tobacco, beedi (Indian cigarette) or snuff nearly every day?", responses were binary 0 (No) and 1 (Yes) and, "Do you still use tobacco regularly?", responses were binary 0 (No) and 1 (Yes). Responses for the 2 questions were then categorized into 0 (Non-smoker), 1 (Ex-smoker) and 2 (Current smoker).

Alcohol use: Participants provided responses for the following question, "Was there ever a period in your life when you drank at least 12 drinks in a year?" Responses were 0 (Never drank alcoholic drinks), 1 (No, less than 12 drinks in a year), 2 (Yes, more than 12 drinks a year). Responses were recoded as 0 (Never drank alcoholic drinks), original responses 1 and 2 were recoded as 1 (Yes, ever drank alcoholic drinks).

Body Mass Index (BMI) and Waist-Hip-Ratio (WHR): Body mass index was calculated by the division of weight with height. Those with BMI $\geq$30kg/m^2 were considered obese[15]. Waist-hip-ratio is a measurement of abdominal obesity, measured by a ratio of waist to hip circumference. Males with waist-hip-ratio greater than 0.90 and females greater than 0.80, were considered to be obese[15].

Geriatric Mental State-Automated Geriatric Examination for Computer Assisted Taxonomy (GMS-AGECAT, Depression): A diagnostic assessment for depression as well as other mental illnesses that uses a computerized algorithm (AGECAT) to make diagnoses. 5 levels of severity are generated from 0 (none) to 5 (severe). A severity level 0 would indicate no depression; levels 1-3 indicate subsyndromal depression, levels 4-5 indicate DSM-IV depression. For the purpose of this analysis, responses were recoded as binary responses 0 (levels 1-3), 1 (levels 4 and 5). Inter-rater agreement on depression diagnoses between AGECAT and psychiatrists' achieved a kappa value of 0.88[16].

A cognitive test battery comprising two cognitive tests, a) the community screening instrument for dementia (CSI'D) which incorporated the animal naming verbal fluency task by the Consortium to Establish a

Registry for Alzheimer's Dementia (CERAD), and b) a 10 word-list learning task with delayed recall by CERAD (modified). An aggregated score (COGSCORE) was generated by taking the summation of all item-weighted scores of the entire cognitive test battery.

10/66 Dementia: A 10/66 dementia diagnosis was given to older adults based on a cut-off determined by logistic regression coefficients of CSI'D COGSCORE, RELSCORE (unweighted total informant score of functional and cognitive decline in the older adult), GMS/AGECAT, and the modified CERAD. A cut-off of more than 0.25 was used as it produced the best sensitivity and specificity to identify dementia cases.[17] Validation of the 10/66 diagnosis revealed that it had a substantial agreement with clinician diagnosis in the WiSE study.[14]

World Health Organisation-Disability Assessment Schedule (WHO-DAS) 2.0: It is a 12-item questionnaire which assesses 6 domains of functioning in cognition, mobility, self-care, getting along, life activities and participation (WHODAS). Item responses range from 0 (no difficulty) to 4 (extremely difficulty or cannot do). A total WHO-DAS score is calculated by the summation of the domain scores.

Care need: defined as the amount of care needed by the older person that is provided by the informant. Informants were asked to respond to whether: the older person needs care much of the time (1), needs care occasionally (2), does not need care; they are able to do everything for themselves (3).

Statistical Analysis

Statistical analyses were carried out using the SAS System version 9.3. All of the statistical analyses used in this study were based on weighted data. First, simple logistic regression was used to analyze the correlates of stroke prevalence at a univariate level. Second, multiple logistic regression was used to analyze socio-demographic and health correlates of stroke at a multivariate level. Socio-demographic factors such as age group, gender, ethnicity, education and health or lifestyle conditions such as hypertension, heart trouble, diabetes, smoking, alcohol use, depression and dementia were used as predictors in both regression analyses. Associations with cognitive and disability scores were estimated using multiple linear regressions, while association with care needs was estimated using multinomial logistic regression after accounting for covariates. Statistical significance was set at a conventional cut-off point at P<.05, two-tailed.

The target sample size was determined by a power calculation for binary proportions. After adjusting for design effect for the overall prevalence estimate, subgroups by age and ethnicity with the precision of 5%, it was estimated that a sample size of 2500 was sufficient in providing adequate precision.[14]

Results

The characteristics of the sample population were summarized in table 1. In all, 2562 participants were included in the current analysis. Overall response rate was 65.6% (2565/3913). The mean age was approximately 70 years old (M=69.9, SD=7.85). Participants comprised 43.6% males and 56.4% females. The sample comprised 39.4% Chinese, 29.1% Malay, 30.1% Indian, and other ethnicities 1.4%.

Table 1: Descriptive characteristics of the sample population.

						Singapore's general population 2011	
Variable	Category	n	Unweighted %	Weighted %	SE	N (000)	%
Age group	60-74	1493	58.3	75.1	0.02	420.5	75.0
	75-84	668	26.1	19.4	0.02	109.1	19.5
	85+	401	15.7	5.5	0.01	31.0	5.5
Gender	Men	1116	43.6	44.1	1.41	258.9	46.2
	Women	1446	56.4	55.9	1.41	301.7	53.8
Ethnicity	Chinese	1009	39.4	83.3	0.03	467.0	83.3
	Malay	745	29.1	9.3	0.01	52.00	9.3
	Indian	772	30.1	6.0	0.02	33.50	6.0
	Others	36	1.4	1.4	0.01	8.10	1.4
Education	None	510		16.4	0.98		
	Some, but did not complete primary	620		24.0	1.21		
	Completed primary	639		24.8	1.23		
	Completed secondary	517		22.4	1.20		
	Completed tertiary	262		12.4	0.97		
Smoking	No	1888		74.5	1.21		
	Ex-smoker	438		15.9	0.99		
	Current smoker	236		9.5	0.83		
Body-Mass-Index (BMI) †	<30 kg/m^2 (Not obese)	1969		91.4	0.75		
	≥30kg/m^2 (Obese)	318		8.6	0.75		
Waist hip ratio (WHR) ‡	Low	401		20.2	1.20		
	High	1924		79.8	1.20		
Drinkers	No	1579		48.2	1.40		

	Yes	983			51.8	1.40	
GMS Depression	Yes	176			3.7	0.45	
	No	2386			96.3	0.45	
Hypertension	No	1010			40.6	1.39	
	Yes	1549			59.4	1.39	
Heart problem	No	2106			86.7	0.90	
	Yes	449			13.3	0.90	
Diabetes	No	1756			74.5	1.21	
	Yes	798			25.5	1.21	
10/66 dementia	No	2021			90.0	0.70	
	Yes	398			10.0	0.70	

†Criteria based on WHO BMI cut-off for obesity; ‡Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

Out of 2562 older adult participants, 199 respondents reported that they had ever been told by a doctor to have had stroke. Missing answers were deleted listwise. The overall weighted stroke prevalence was 7.6%, 95%CI[6.2,9.0] among older adult residents aged 60 years and above. Weighted stroke prevalence for those aged 65 years and above was 9.3%. A detailed breakdown of the prevalence of stroke by socio-demographic and health variables were presented in table 2.

Table 2. Number of stroke and non-stroke cases by sociodemographic and health factors.

		Without stroke			Stroke		
Variable	Category	n	%	SE	n	%	SE
Age group	60-74	1415	94.3	0.8	78	5.7	0.8
	75-84	599	87.4	1.8	69	12.6	1.8
	85+	349	84.5	2.4	52	15.5	2.4
Gender	Men	1033	92	1.1	83	8	1.1
	Women	1330	92.7	0.9	116	7.3	0.9
Ethnicity	Chinese	913	92.2	0.8	96	7.8	0.8
	Malay	704	94.9	0.9	41	5.1	0.9
	Indian	715	93.7	0.9	57	6.3	0.9
	Others	31	85.6	6.1	5	14.4	6.1
Education	None	455	87.8	2.1	55	12.2	2.1
	Some, but did not complete primary	566	91.8	1.5	54	8.2	1.5
	Completed primary	596	93.4	1.4	43	6.6	1.4
	Completed secondary	485	93.7	1.4	32	6.3	1.4
	Completed tertiary	249	95.5	1.7	13	4.5	1.7
Smoking	No	1749	93.2	0.8	139	6.8	0.8
	Ex-smoker	393	87.7	2.2	45	12.3	2.2
	Current smoker	221	93.8	2.2	15	6.2	2.2
BMI†	<30 kg/m^2 (Not obese)	1850	94.1	0.7	119	5.9	0.7

	≥30kg/m^2 (Obese)	304	94.1	2.3	14	5.9	2.3
WHR‡	Low	382	96	1.2	19	4	1.2
	High	1809	93.5	0.8	115	6.5	0.8
Drinkers	No	1451	91.4	1.1	128	8.6	1.1
	Yes	912	93.3	1	71	6.7	1
Depression	Yes	156	86.7	4.5	20	13.3	4.5
	No	2207	92.6	0.7	179	7.4	0.7
Hypertension	No	972	97.3	0.7	38	2.7	0.7
	Yes	1388	89	1.1	161	11	1.1
Heart problem	No	1981	94.4	0.7	125	5.6	0.7
	Yes	377	79.8	2.9	72	20.2	2.9
Diabetes	No	1657	94.5	0.7	99	5.5	0.7
	Yes	699	86.3	1.8	99	13.7	1.8
10/66 dementia	No	1913	94.9	0.7	108	5.1	0.7
	Yes	214	69.7	3.7	84	30.3	3.7

†Criteria based on WHO BMI cut-off for obesity; ‡Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

Socio-demographic and health correlates of stroke

Simple logistic regression revealed that sociodemographic features such as older age, no education, ex-smokers were associated with higher stroke prevalence (p<.05). Stroke was 2.3 times more prevalent in the 75-84 age group, and 3 times more prevalent in the above 85 years old age group as compared to the younger age group 60-74. Stroke was 3 times more prevalent in those who self-reported no education than those who have completed tertiary education. Stroke prevalence was 2 times higher among ex-smokers than those who had never smoked. Malay ethnicity was associated with lower stroke prevalence (p<.05), having 0.6 times lower stroke prevalence as compared to ethnic Chinese.

Health conditions such as hypertension, heart trouble, and diabetes significantly predicted stroke prevalence (p<.001) at the univariate level. Stroke was more prevalent among those who self-reported having hypertension (4.5 times), heart trouble (4.2 times), diabetes (2.7 times), and dementia (8 times) as compared to those without the respective health conditions. Gender, obesity (BMI and WHR), alcohol consumption and depression were not associated with stroke prevalence in this study.

Multivariate logistic regression revealed that only hypertension, heart trouble, diabetes and 10/66 dementia were independently associated with stroke prevalence (p<.05). At the multivariate level, stroke prevalence was also higher among those with self-reported hypertension (4.6 times), heart trouble (2.5 times), diabetes (2.6 times), and 10/66 dementia (3.6 times) as compared to those without the respective health

conditions. Ethnic differences maintained significance at the multivariate level – ethnic Malays had significantly lower (0.4 times) stroke prevalence when compared to ethnic Chinese. There was no significant difference in stroke prevalence between Indian and Chinese ethnicities.

Age group, gender, education, depression and other lifestyle (smoking, alcohol, BMI, and WHR) conditions were not associated with stroke prevalence (p>.05) at a multivariate level. The complete results of the socio-demographic and health correlates of stroke were presented in table 3.

Cognition, disability and care needs correlates of stroke

After adjusting for sociodemographic and health covariates in multiple linear regression analyses, stroke was negatively associated with cognitive scores (β= -1.15, p=.0011) and positively associated with disability scores (β= 9.01, p<.001). This meant that respondents with stroke were associated with greater cognitive deficits as well as greater physical disabilities.

Table 3. Sociodemographic and health correlates of stroke.

		Simple logistic regression				Multiple logistic regression			
variable	categories	OR	95% Wald Confidence Intervals (CI)		*p*	OR	95% Wald Confidence Intervals (CI)		*p*
Age group	60-74	ref				ref			
	75-84	2.38	1.54	3.69	<0.001	1.23	0.67	2.25	0.498
	85+	3.04	1.90	4.87	<0.001	0.79	0.31	2.02	0.627
Gender	Men	ref				ref			
	Women	0.91	0.61	1.37	0.657	0.73	0.37	1.42	0.347
Ethnicity	Chinese	ref				ref			
	Malay	0.63	0.41	0.96	0.030	0.41	0.20	0.82	0.012
	Indian	0.79	0.55	1.15	0.217	0.61	0.33	1.11	0.103
	Others	1.98	0.74	5.36	0.176	2.71	0.81	9.13	0.107
Education	None	2.94	1.22	7.09	0.017	1.24	0.38	4.04	0.725
	Some, but did not complete primary	1.89	0.78	4.58	0.161	1.23	0.39	3.90	0.720
	Completed primary	1.50	0.60	3.74	0.388	1.66	0.49	5.69	0.418
	Completed secondary	1.43	0.57	3.62	0.447	1.30	0.42	4.10	0.651
	Completed tertiary	ref				ref			
Smoking	Non-smoker	ref				ref			
	Ex-smoker	1.94	1.22	3.10	0.006	1.75	0.80	3.82	0.160
	Current smoker	0.92	0.42	2.03	0.830	1.15	0.44	2.98	0.774
Obesity[†]	<30 kg/m^2 (Not obese)	ref				ref			
	≥30kg/m^2 (Obese)	1.00	0.43	2.32	0.996	1.17	0.44	3.13	0.757
Waist-Hip-Ratio[‡]	Low	ref				ref			
	High	1.67	0.84	3.33	0.143	1.24	0.57	2.69	0.590

Table 3. Sociodemographic and health correlates of stroke (continued).

variable	categories	Simple logistic regression				Multiple logistic regression			
		OR	95% Wald Confidence Intervals (CI)		*p*	OR	95% Wald Confidence Intervals (CI)		*p*
Alcohol	No	ref				ref			
	Yes	0.77	0.51	1.15	0.201	0.56	0.30	1.06	0.076
Depression (AGECAT)	No	ref				ref			
	Yes	1.92	0.87	4.26	0.109	0.76	0.21	2.84	0.687
Hypertension	No	ref				ref			
	Yes	4.52	2.55	8.00	<0.001	4.58	1.84	11.40	0.001
Heart trouble	No	ref				ref			
	Yes	4.25	2.75	6.58	<0.001	2.45	1.30	4.63	0.006
Diabetes	No	ref				ref			
	Yes	2.72	1.80	4.12	<0.001	2.60	1.49	4.53	0.001
10/66 Dementia	No	ref				ref			
	Yes	8.06	5.19	12.52	<0.001	3.57	1.57	8.12	0.002

OR: Odds ratio; [†]Criteria based on WHO BMI cut-off for obesity; [‡]Criteria based on WHO waist-hip-ratio cut-off for >.80 females, >.90 males;

After adjusting for covariates in multinomial logistic regression analysis, stroke and care needs were found to be positively associated (p<.0001). Among older adults with stroke, there was a 4 and 10 times increase in the odds of needing care "occasionally" and "much of the time" respectively when compared to those with stroke who "did not need care". The results of the correlates of stroke with cognitive, disability scores and care needs were presented together in Table 4.

Table 4. Relationship between stroke and cognitive, WHO-DAS, and care needs scores.

Cognitive and Disability Scores	Without stroke			With stroke			B†	SE	*P*	95% CI	
	n	Mean	SE	n	Mean	SE					
Cognitive Score	2363	28.6	0.09	199	22.6	0.91	-1.15	0.45	0.011	-2.04	-0.27
Who-DAS	2363	8.70	0.36	199	37.0	3.26	9.01	2.07	<0.001	4.96	13.07
	n	%	SE	n	%	SE	OR‡	SE	*P*	95% CI	
Needs care much of the time	237	57.7	4.40	92	42.3	4.40	10.1	0.43	<0.001	4.35	23.31
Needs care occasionally	320	84.3	3.11	43	15.7	3.11	4.09	0.40	<0.001	1.86	9.01
Does not need care	1670	96.5	0.61	57	3.50	0.61	ref				

†*B* coefficient derived from multiple linear regression analysis after adjusting for sociodemographic and health covariates,
‡OR derived from multinomial logistic regression analyses after adjusting for sociodemographic and health covariates.

Discussion

Stroke prevalence

The weighted stroke prevalence found in this study was 7.6% among the older adults aged 60 and above. In an earlier population-based study that was conducted in Singapore in the year 2001 to 2003, stroke prevalence among older adults aged 65 and above was found to be 7.7%.[18] For the purpose of comparison, weighted stroke prevalence among those 65 years and above was found to be 9.3% in this study, which was higher as compared to the figures reported by the earlier study.[18]

Stroke prevalence found in this study was comparable to the figures reported in Western populations, such as 8.3% in the United States among older adults 65 years and above.[19] However the figures were higher than that reported in several non-western ageing populations, such as 4.5% in Korea[20], 4.9% in Hong Kong[21], and 2.7% in Thailand[22] among older adults aged 65 years and above.

In the previous study, stroke prevalence among the three major ethnic groups (Chinese, Malay, Indian) was found to range from 3.32% to 3.75%.[18] Chinese ranked the highest in prevalence, followed by Indian and Malay ethnicities. While the ranking remained the same in this study, there was an increase in stroke prevalence

across all 3 ethnic groups, ranging from 5.1% to 7.8%. While the previous study did not find ethnic differences in stroke prevalence, the WiSE study found significant differences between the Chinese and Malay ethnicities with ethnic Malays having significantly lower stroke prevalence as compared to ethnic Chinese. These results were unexpected because according a recent the National Health Survey (2010), the Malay ethnicity has been associated with various stroke risk factors such as hypertension and obesity.[23] There appears to be no clear explanations for our findings, however as it was previously reported that ethnic minority groups, such as ethnic Malays, have a lower tendency of self-rating poor health,[24] it is possible that either they did not want to mention being diagnosed, they were not diagnosed or did not remember being diagnosed with stroke. Additionally, according to the Singapore's census population statistics (2010), it has been reported that those belonging to the Malay ethnic group have the lowest median household income.[25] Thus it could be possible that they have fewer opportunities to be informed about their health, which could also explain the lower self-reported stroke. As stroke prevalence data in Singapore is scarce, comparisons with past studies are insufficient, thereby making it difficult to draw sound conclusions. Future research could take into account any administrative data or registries to draw clearer outcomes on ethnic differences in stroke epidemiology.

Sociodemographic correlates of stroke

Age was significantly associated with stroke prevalence at a univariate level, a finding that was consistent with past research.[18, 26] After controlling for sociodemographic and health conditions however the association disappeared. These findings were consistent with an earlier study that examined stroke risk factors and stroke prevalence among Thai adults aged 45 to 80 years, where older age was not associated with higher stroke prevalence after all other factors were considered.[22] Unexpectedly, gender was not associated with stroke prevalence in this study and it is unclear why this is so.

Biological changes that come with old age may affect existing age/gender association with stroke risk factors, which in turn may contribute to the lack of association between age/gender and stroke prevalence. Hypertension, diabetes and cardiovascular complications usually arise with increasing age. For instance, increased high blood pressure is greatly attributed to the changes to the cardiovascular system, structure of arteries and large artery stiffness that come with age.[27, 28] Cardiovascular problems and diabetes are usually associated with a sedentary lifestyle of old age.[29,30] By the age of 60 to 69 years, women have a higher risk of developing hypertension due to menopause.[31] However, research has also shown that certain health conditions become less prevalent with increasing age. In one study, existing age/gender associations with

several stroke risk factors tend to diminish or change among older age groups (70 to 80 years) and especially for men.[32] Our findings suggest that health complications that come with age and gender may have been better predictors of stroke prevalence among older adults in this study.

Health correlates of stroke

The WiSE study found that hypertension, heart trouble, and diabetes were independently associated with stroke prevalence. These findings were expected since these health conditions are established determinants of stroke [3]. Stroke was also associated with 10/66 dementia, which is also an expected finding since stroke and Alzheimer's disease have various overlapping risk characteristics.[17, 33]

Obesity was not associated with stroke prevalence. While it was not unexpected that there was no association between BMI and stroke risk, WHR was an unexpected finding since WHR was found to be a stronger predictor of stroke risk than BMI.[34,35] Our findings however were similar to the aforementioned study among Thai older adults. In both studies, BMI was not a significant predictor at a univariate level and WHR did not independently predict stroke prevalence at a multivariate level.[22] Having ever smoked (current and ex-smokers) and alcohol consumption were not associated with stroke prevalence among older adult residents. These results were unanticipated however as research has shown that these factors are dose-dependent,[36, 37, 38, 39] it could be possible that the sample of older adult respondents in this study were not heavy smokers and did not consume alcohol excessively.

Stroke prevalence was not associated with depression in this study. Our finding differed from several other existing studies and meta-analyses which found otherwise.[5,40] Although meta-analyses have shown a positive association, majority of the studies included in these meta-analyses did not take into adequate account of stroke risk factors such as BMI or alcohol use.[41] The results of this study were consistent with at least one prospective study which found that depression was not associated with stroke risk amongst older adults, after adequately controlling for covariates.[42,43] Taken together, depression did not appear to be a relevant risk factor of stroke in older adults.

Stroke, disability and care need

As expected, stroke was found to be associated with low cognitive and high disability scores. Stroke is among the top 3 leading cause of disability among older adults aged 65 years and above in Singapore and involves long term dependency on healthcare services.[44] Despite the severity of stroke disability, a substantial

number of stroke patients would not go for post-stroke therapy citing high financial costs, inconvenience, and lack of interest.[45]

Our study revealed stroke to be associated with greater care needs. In Singapore, given that close to 95% of older adult residents stay with family members[46] and that age-related diseases will rise in view of the ageing population in Singapore, it is expected that there will be a substantial increase in burden and reliance on family members for their daily needs if disabled. These findings thus indicate the need to extend and improve on existing services not only to stroke survivors, but also to caregivers.

This study has some limitations, with foremost the nature of self-reported stroke which may be subjected to errors such as false reporting resulting in over or under-estimation of stroke prevalence. However, most population-based prevalence studies utilize self-report for ease of administration, cost-effectiveness and ease of direct comparison with the majority of studies which used similar methods. Third, as this is a cross-sectional study, temporal relationships between stroke and other factors cannot be established.

Future research should take into consideration the importance of establishing stroke incidence to provide a well-informed understanding of stroke epidemiology in Singapore. Published research articles on stroke incidence in Singapore are rare- the most recent study was published in the year 2000.[47] In Adelaide, possibly owing to advances in healthcare intervention and public initiatives, stroke incidence rates have declined despite an ageing population.[48,49] At the present juncture it remains unclear whether recent incidence estimates of stroke have increased or decreased relative to past data and worldwide in Singapore.

Conclusion

The prevalence of stroke survivors in Singapore is relatively high when compared to other Asian countries. Our findings provide support for the existing body of research on stroke prevalence and its correlates. Given that Singapore's population is ageing rapidly, our findings may indicate a need to review existing support services for stroke survivors and their caregivers. Finally, future research could take into consideration incidence rates to present a more relevant understanding of stroke epidemiology in Singapore, and also investigate the role of gender, ethnicity, and lifestyle risk factors such as smoking, alcohol use and obesity on stroke prevalence to confirm the findings of this study.

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Author contributions

Author Wen Lin Teh wrote the first draft of the manuscript. Author Edimansyah Abdin provided statistical analysis. Janhavi Ajit Vaingankar, Esmond Lee Seng Seow, Vathsala Sagayadevan, Saleha Shafie, Shazana Shahwan, Yun Jue Zhang were involved in data collection and literature review searches. Author Mythily Subramaniam and Siow Ann Chong wrote the protocol and designed the study. Li Ling Ng provided intellectual input in the area of data collection and analyses. All authors contributed to and have approved the final manuscript.

Data Sharing

Data are not available for online access; however, readers who wish to gain access to the data can write to the senior author (MS) at mythily@imh.com.sg with their requests. Access can be granted and subjected to the Institutional Review Board (IRB) and the research collaborative agreement guidelines. This is a requirement mandated for this research study by our IRB and funders.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 to 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	5
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6,7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	6 to 12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10,11
		(*b*) Report category boundaries when continuous variables were categorized	5
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	4,5,6
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	12 to 15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.