The Modified Mini-Mental State Examination test: normative data for Singapore Chinese older adults and its performance in detecting early cognitive impairment

Lei Feng[1], BMed, PhD, *Mei Sian Chong*[2], MRCP, FAMS, *Wee Shiong Lim*[2], MRCP, MMed, *Tze Pin Ng*[1], MFPHM, FAMS

INTRODUCTION This study aimed to determine the stratified normative data by age and education for a modified version of the Mini-Mental State Examination (MMSE) test from a large sample of community-dwelling Chinese older adults in Singapore, and to examine the MMSE's value in detecting early cognitive impairment.
METHODS We studied 1,763 Chinese older adults with normal cognitive function and 121 Chinese older adults with early cognitive impairment (Clinical Dementia Rating global score 0.5). Normative MMSE values were derived for each of the 15 strata classified by age (three groups) and education level (five groups). Receiver operating characteristic curve analysis was conducted for the whole sample and each of the three education subgroups (no education, primary, secondary and above).
RESULTS Education level and age significantly influenced the normative values of MMSE total scores in Chinese older adults with normal cognitive function. For the purpose of detecting early cognitive impairment, an optimal balance between sensitivity (Se) and specificity (Sp) was obtained at a cutoff score of 25, 27 and 29 for each of the three education groups, respectively. For the whole sample, the optimal cutoff point was 26 (Se 0.61, Sp 0.84, area under curve 0.78).
CONCLUSION Age and education level must be taken into account in the interpretation of optimal cutoffs for the MMSE. Although widely used, the MMSE has limited value in detecting early cognitive impairment; tests with better performance should be considered in clinical practice.

Keywords: cognitive impairment, dementia, Mini-Mental State Examination, sensitivity and specificity
Singapore Med J 2012; 53(7): 458–462

INTRODUCTION

The Mini-Mental State Examination (MMSE) is the most commonly used screening tool for cognitive impairment and dementia worldwide.(1) A number of studies have examined the accuracy of the MMSE in the detection of dementia.(2) In Singapore, a localised MMSE version discriminated well between elderly with and without dementia (cutoff 23/24, sensitivity 97.5%, specificity 75.6%).(3) High sensitivity (90.8%) and specificity (93%) were also reported from a pure Chinese study sample in China.(4)

While the screening and diagnosis of established dementia syndrome is not unduly difficult for an experienced specialist, it is much more challenging to identify persons with early cognitive impairment without clear outward manifestations, as at this stage, many patients only have subtle cognitive deficit and are able to perform their daily activities well. Furthermore, age and education level significantly influence an individual's cognitive performance in late life,(3-6) and a single unadjusted cutoff score provides limited value in real practice where patients with diverse educational background are assessed. To this end, detailed age- and education-specific normative values and cutoff scores would provide much added value.

Using data from the Singapore Longitudinal Ageing Study (SLAS) cohort, the present study aimed to report the normative data of the MMSE (mean and standard deviation; 5, 10, 25, 50 and 75 percentiles) for Chinese older adults aged ≥ 55 years and assess the utility of the MMSE in detecting early cognitive impairment. The data would be useful for local clinical practice, as well as for future research on dementia and cognitive impairment in the Chinese elderly.

METHODS

The subjects in the present study were identified from participants in the SLAS, a community-based epidemiological study of ageing and health. Details of the study have been described elsewhere.(7) Briefly, all residents (Singapore citizens and permanent residents) in the South-East Region of Singapore aged ≥ 55 years were identified from a door-to-door census, and invited to participate in the study. The study was approved by the National University of Singapore Institutional Review Board, and informed consent was obtained from all the participants (response rate 78.2%).

A total of 2,808 participants completed baseline assessments from September 2003 to December 2005. Among them, 1,850

[1]Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, [2]Department of Geriatric Medicine, Tan Tock Seng Hospital, Singapore
Correspondence: A/Prof Ng Tze Pin, Associate Professorial Fellow, Department of Psychological Medicine, National University of Singapore, NUHS Tower Block, 1E Kent Ridge Road, Singapore 119228. pcmngtp@nus.edu.sg

participants completed a follow-up assessment conducted from March 2005 to September 2007. To extract the normative MMSE data in the study sample, we selected 1,763 Chinese older adults with normal cognitive function after excluding participants with missing baseline MMSE data (n = 15), non-Chinese ethnicity (102 Malay, 60 Indian and 28 other races), and those who met the criteria for being considered 'abnormal' (n = 840). A subject was considered 'abnormal' if any of the following criteria were met: (1) baseline MMSE total score < 18; (2) Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) score > 3.3;[8] (3) MMSE total score decline ≥ 1 per year during the time interval between baseline and follow-up assessment; (4) global Clinical Dementia Rating (CDR) score > 0; (5) self-reported dementia, Parkinson's disease, stroke, and mental illness; and (6) Geriatric depression scale (GDS) total score ≥ 5 at baseline.[9] Due to incomplete data for the above measures in 2,603 participants, we used multiple measures in defining 'abnormal' to ensure rigour in the definition of normalcy in our sample (data available: baseline MMSE n = 2,603; GDS n = 2,599; follow-up MMSE n = 1,726; IQCODE n = 983; CDR n = 308). Fig. 1 depicts the flow of subjects in the study.

Among the 308 Chinese participants who had received a CDR assessment at baseline, 121 were assigned a CDR global score of 0.5 and defined as 'early cognitive impairment'. Receiver operating characteristic (ROC) curve analysis was conducted on the combined sample (the 121 participants with early cognitive impairment and the 1,763 participants with normal cognition). Cognitive function was assessed by the Modified Mini-Mental State Examination by trained research nurses.[3] The test was developed based on the original MMSE and the Chinese version of MMSE developed by Zhang et al in Shanghai.[10,11] The test measures global cognitive functioning on domains that include memory, attention, language, praxis and visuospatial ability. The summed scores of MMSE ranged from 0 to 30, with higher values denoting better cognitive functioning. The test was administered in Chinese, English or dialects, according to the participants' habitual language.

A summary of the modifications is shown below with reasons/justifications in brackets.

1) The question on seasons was replaced with the question "Without looking at your watch, what time is it?" (Q5, there are no seasons in Singapore).

2) The question on city/town was replaced with the question "What area are we in?" (Q8, Singapore is a city country; for this question, the only correct answer is Singapore).

3) The question on state/province was replaced with the question "Which part of Singapore is this place (North, South, East, West or Central)?" (Q10, Singapore is a city country).

4) For immediate recall (Q11–Q13) and delayed recall (Q19–Q21), "ball, flag, tree" were used in the English version, and "柠檬，锁匙，气球" (lemon, key, balloon) were used in the Chinese version

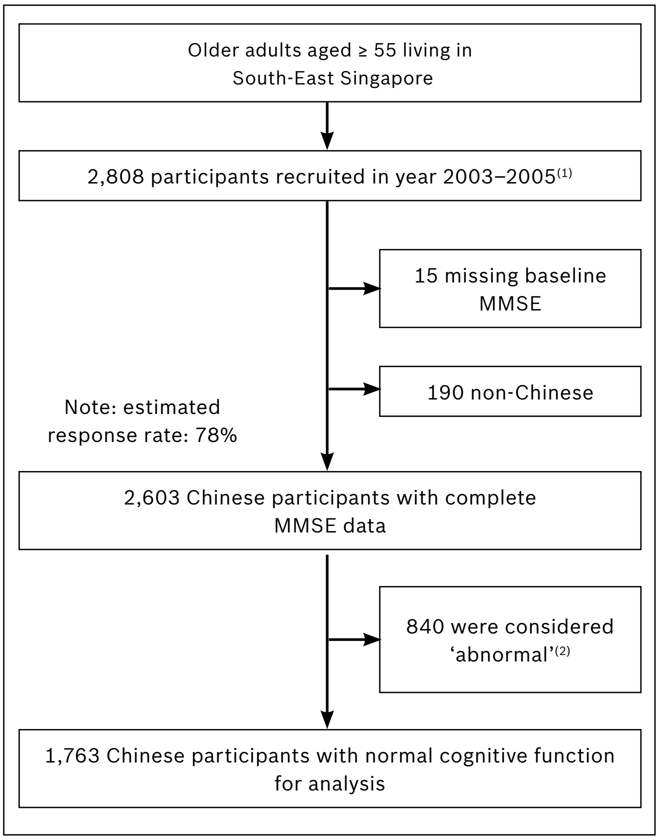

Fig. 1 Flow chart of the 1,763 normal subjects in the study.

(in local Chinese language, ball, flag and tree are single-syllable words).

5) For sentence repetition, "no ifs, ands or buts" in the English version was used and "四十四只石狮子" (forty-four stone lions) was used in the Chinese version (Q24, direct translation of the original English sentence is meaningless).

The CDR was administered by trained researchers with medical background.[12,13] A CDR global score of 0 indicates no dementia, while 0.5, 1, 2 and 3 indicate questionable or very mild, mild, moderate and severe dementia, respectively. Details on CDR and some modifications have been described elsewhere.[14] In the present study, we used a CDR score of 0.5 to define early cognitive impairment. Information on age, gender and education level of participants was collected by research nurses through face-to-face interviews.

The values for mean and standard deviation (SD) derived from the MMSE total score were reported for each of the 15 strata formed by age group (55–64, 65–74, ≥ 75 years) and education level (nil, primary school, secondary school or equivalent, pre-university or polytechnic, university and above). The 5th, 10th, 25th, 50th and 75th percentile values were also reported, since the information could be useful for clinical reference. ROC curve analysis was conducted for the whole sample, and each of the three education subgroups: no education; primary school; and secondary school and above. Sensitivity, specificity and area under curve (AUC) values were reported. All statistical analysis was performed using the Statistical Package for the Social Sciences version 18.0 (SPSS Inc, Chicago, IL, USA).

Table I. Characteristics of the study subjects.

Variable	No. (%)		p-value*
	Normal cognition (n = 1,763)	Early cognitive impairment (n = 121)	
Mean age ± SD (yrs)	65.0 ± 7.0	68.8 ± 7.3	< 0.001
Age group (yrs)			
55–64	956 (54.2)	41 (33.9)	< 0.001
65–74	651 (36.9)	58 (47.9)	
≥ 75	156 (8.8)	22 (18.2)	
Gender			
Female	1,122 (63.6)	81 (66.9)	0.442
Education level			
Nil	268 (15.2)	51 (42.1)	< 0.001
Primary	574 (32.6)	44 (36.4)	
Secondary or equivalent	593 (33.6)	19 (15.7)	
Pre-university or polytechnic	197 (11.2)	5 (4.1)	
University and above	131 (7.4)	2 (1.7)	
Mean MMSE total score ± SD	27.6 ± 2.3	24.2 ± 3.6	< 0.001
< 18	0	5 (4.1)	< 0.001
18–23	114 (6.5)	48 (39.7)	
24–26	326 (18.5)	28 (23.1)	
27–30	1,323 (75.0)	40 (33.1)	

Note: Early cognitive impairment was defined as a global CDR score of 0.5.
p-values were calculated using student's *t*-test for continuous variables and chi-square test for categorical variables.
MMSE: Mini-Mental State Examination; SD: standard deviation

Table II. Age- and education-stratified MMSE normative values.

Age (yrs)/education stratum	No. of subjects	Mean MMSE total score ± SD	Percentile				
			5th	10th	25th	50th	75th
55–64							
Nil	60	25.4 ± 3.0	19	21	24	26	28
Primary	271	27.5 ± 1.8	24	25	26	27	29
Secondary or equivalent	392	28.7 ± 1.3	26	27	28	29	30
Pre-university or polytechnic	144	29.1 ± 1.2	27	28	29	29	30
University and above	89	29.3 ± 0.9	28	28	29	30	30
65–74							
Nil	161	24.9 ± 2.9	20	21	23	25	27
Primary	231	27.1 ± 2.0	23	24	26	27	29
Secondary or equivalent	175	28.2 ± 1.6	25	26	27	28	30
Pre-university or polytechnic	45	28.9 ± 1.2	27	27	28	29	30
University and above	39	28.7 ± 1.4	25	27	28	29	30
≥ 75							
Nil	47	23.9 ± 2.8	19	20	22	24	26
Primary	72	26.3 ± 2.4	22	22	25	27	28
Secondary or equivalent	26	27.9 ± 1.7	24	25	27	28	29
Pre-university or polytechnic	8	27.4 ± 2.0	-	-	-	-	-
University and above	3	27.7 ± 1.5	-	-	-	-	-
Total sample	1,763	27.6 ± 2.3	23	24	27	28	29

MMSE: Mini-Mental State Examination; SD: standard deviation

RESULTS

As shown in Table I, subjects with early cognitive impairment (age 68.8 ± 7.3 years) were older than those with normal cognition (65.0 ± 7.0), and there were more subjects without any formal education in the early cognitive impairment group (42.1%) compared to the normal subjects (15.2%). Total MMSE scores were lower in the early cognitive impairment group than in the normal cognition group (24.2 ± 3.6 vs. 27.6 ± 2.3). There was no gender difference between the two groups (p = 0.442).

The mean and SD values of the MMSE total scores for each of the 15 age- and education-stratified groups are shown in Table II. As expected, higher education level was associated with higher MMSE total scores. For instance, the mean MMSE total scores in the age group 55–64 years were 25.4 ± 3.0, 27.5 ± 1.8, 28.7 ± 1.3, 29.1 ± 1.2 and 29.3 ± 0.9, respectively, for each of the five education subgroups (nil, primary school, secondary school or equivalent, pre-university or polytechnic, university and above). For subjects with the same education level, increasing age was associated with decreased MMSE performance. For example, the mean MMSE total scores among subjects with a primary school education decreased from 27.5 ± 1.8 to 27.1 ± 2.0 and 26.3 ± 2.4 across the three age groups (55–64, 65–74, ≥ 75 years,

Table III. Sensitivity and specificity estimates of detection of early cognitive impairment using the MMSE test.

	No education (n = 319)		Primary (n = 618)		Secondary & above (n = 947)		Total (n = 1,884)	
	Se	Sp	Se	Sp	Se	Sp	Se	Sp
Cutoff score								
< 24	0.65	0.70	0.36	0.95	0.15	0.99	0.44	0.94
< 25	**0.75**	**0.68**	0.48	0.90	0.23	0.99	0.54	0.90
< 26	0.84	0.46	0.57	0.83	0.23	0.97	**0.61**	**0.84**
< 27	0.86	0.32	**0.68**	**0.67**	0.27	0.93	0.67	0.75
< 28	0.92	0.18	0.86	0.48	0.39	0.83	0.79	0.62
< 29	0.96	0.09	0.89	0.28	**0.65**	**0.64**	0.87	0.44
AUC	0.706		0.758		0.672		0.783	

Note: Figures in bold show Se and Sp values at optimal cutoff closest to the top left corner of the receiver operating curves.
MMSE: Mini-Mental State Examination; Se: sensitivity; Sp: specificity; AUC: area under curve

respectively). Age and education influences were also evident on the percentile cutoff values (except for some groups with small sample sizes). For the whole sample, the 10th percentile value was 24, which corresponds with the conventional cutoff for dementia screening as well as the cutoff reported in an earlier local study.[3]

The sensitivity and specificity estimates for MMSE cutoff scores of 24–29 are shown in Table III. The influence of education level was obvious; among subjects who had no formal education, the traditional cutoff score of 24 yielded moderate sensitivity (0.65) and specificity (0.70). In contrast, very low sensitivity (0.36 and 0.15, respectively) and very high specificity (0.95 and 0.99, respectively) were obtained at this cutoff for subjects with primary education and subjects with at least secondary education. For the whole sample, using a cutoff of < 24, the sensitivity was 0.44 and the specificity was 0.94. As expected, the sensitivity estimates increased and the specificity decreased with increasing cutoff scores. An optimal balance between sensitivity and specificity was obtained at a cutoff score of 25, 27 and 29 for subjects with nil, primary and secondary school and above education levels, respectively. For the whole sample (regardless of education level), the optimal cutoff point was < 26 (Se 0.61, Sp 0.84, AUC = 0.783).

DISCUSSION

In a large sample of community-dwelling Chinese older adults aged ≥ 55 years, we reported the population-based normative values of the MMSE and examined its performance in detecting early cognitive impairment. We believe that the results would be a useful reference for the practice of local clinicians and psychologists. The influence of age and education on cognitive performance has been well documented in previous studies,[3,5] and was also evident in our data. The influence of education is especially relevant for clinical practice in Singapore given the heterogeneous educational backgrounds of the local elderly population. Practitioners should bear in mind that an individual without formal school education could be normal (disease-free) even though he/she may obtain a low score on the MMSE test. Conversely, consistent with the cognitive reserve hypothesis,[15,16] an individual with high educational achievement could perform well even at an early stage of dementia. Given the above reasons, age- and education specific normative values and cutoff points (as opposed to a single unadjusted value) should be used in clinical practice and in community screening programmes for early cognitive impairment that employ the MMSE as a cognitive screening tool.

Our study sample comprised a younger and more educated subgroup from the Singapore Chinese elderly population. According to the Singapore Census 2000, among Chinese older adults aged ≥ 55 years, 17.4% were aged 75+ years and only 9.8% had more than ten years of education.[17] In the present study, the corresponding values were 8.8% and 18.6%, respectively. Furthermore, the five subgroups of the normal sample had a sample size of < 50 (8–45); thus, caution should be exercised when applying the norms from these groups.

Due to constraints in the sample size, our ROC analysis was not further stratified by age. We also excluded Indian and Malay subjects from our study. There were no statistically significant differences in the mean age of SLAS participants cross the three ethnic groups. However, compared with the Chinese, there were fewer females among Indians (63% vs. 50%, p = 0.037). Also, there were statistically significant differences in the education level; the percentages of subjects with primary school and below formal education were 52.1%, 78.4%, and 25.0% (p < 0.001) for Chinese, Malay and Indian participants, respectively. We are expanding the SLAS cohort and hopefully, a more comprehensive set of results with an enlarged sample size could be reported in future.

The value of the MMSE as a screening tool in established dementia is well documented.[3] However, studies examining its value in early cognitive impairment are rare.[2] Mitchell et al analysed five published studies on mild cognitive impairment (MCI) and concluded that the MMSE has very limited value in making a diagnosis of MCI against healthy elderly. The pooled sensitivity and specificity was 62.7% (298 out of 475 true cases) and 63.3% (875 non-cases correctly ruled out from 1,382 healthy elderly), respectively.[2] In the present study, using a CDR global score of 0.5 to define early cognitive impairment, we obtained similar results in subjects with no formal education (Se 0.65 and Sp 0.70 using a cutoff of 24). However, the MMSE had poor sensitivity (and consequently, a high false-negative rate) in detecting early cognitive impairment among educated subjects.

For example, if a cutoff score of 24 (Se 44%) or 26 (Se 61%) is applied to a local Chinese older adult population, 56 and 39 early cognitive impairment cases would be missed out of 100 cases, respectively. Therefore, our findings suggest that the MMSE is a poor screening tool for early cognitive impairment even with the use of age- and education-adjusted cutoffs.

A major limitation in our study was the circular use of the MMSE in defining the study population as well as the subsequent validation of the MMSE. We chose the MMSE as a measure for the definition of normalcy due to the completeness of data relative to other measures. Nonetheless, we also employed other measures such as IQCODE, CDR, self-reporting and GDS to mitigate the effects of circularity.

In conclusion, based on our study findings, the modified MMSE is not a useful screening tool for early cognitive impairment. Our results support the exploration of the utility of other instruments (used alone or in combination) in the detection of early cognitive impairment. Normative and validation studies of some of these candidate tools (such as the Montreal Cognitive Assessment and the Repeatable Battery for the Assessment of Neuropsychological Status) are currently being conducted in the SLAS cohort.[18,19]

REFERENCES

1. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975; 12:189-98.
2. Mitchell AJ. A meta-analysis of the accuracy of the mini-mental state examination in the detection of dementia and mild cognitive impairment.J Psychiatr Res 2009; 43:411-31.
3. Ng TP, Niti M, Chiam PC, Kua EH. Ethnic and educational differences in cognitive test performance on mini-mental state examination in Asians. Am J Geriatr Psychiatry 2007; 15:130-9.
4. Zhang ZX, Zahner GE, Román GC, et al. Dementia subtypes in China: prevalence in Beijing, Xian, Shanghai, and Chengdu. Arch Neurol 2005; 62:447-53.
5. Sahadevan S, Tan NJ, Tan T, Tan S. Cognitive testing of elderly Chinese people in Singapore: influence of education and age on normative scores. Age Ageing 1997; 26:481-6.
6. Sahadevan S, Lim JP, Tan NJ, Chan SP. Psychometric identification of early Alzheimer disease in an elderly Chinese population with differing educational levels. Alzheimer Dis Assoc Disord 2002; 16:65-72.
7. Ng TP, Feng L, Niti M, Kua EH, Yap KB. Tea consumption and cognitive impairment and decline in older Chinese adults. Am J Clin Nutr 2008; 88:224-31.
8. Jorm AF. A short form of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): development and cross-validation. Psychol Med 1994; 24:145-53.
9. Sheikh JI, Yesavage JA. Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. Clinical Gerontology: A Guide to Assessment and Intervention. NY: The Haworth Press, 1986:165-73.
10. Zhang MY, Yu E, He YL. [Instruments for the epidemiological survey of dementia and their applications.] Shanghai Psychiatry 1995; 7:3-5. Chinese.
11. Zhang MY, Katzman R, Salmon D, et al. The prevalence of dementia and Alzheimer's disease in Shanghai, China: impact of age, gender, and education. Ann Neurol 1990; 27:428-37.
12. Hughes CP, Berg L, Danziger WL, Coben LA, Martin RL. A new clinical scale for the staging of dementia. Br J Psychiatry 1982; 140:566-72.
13. Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. Neurology 1993; 43:2412-4.
14. Li M, Ng TP, Kua EH, Ko SM. Brief informant screening test for mild cognitive impairment and early Alzheimer's disease. Dement Geriatr Cogn Disord 2006; 21:392-402.
15. Richards M, Deary IJ. A life course approach to cognitive reserve: a model for cognitive aging and development? Ann Neurol 2005; 58:617-22.
16. Kemppainen NM, Aalto S, Karrasch M, et al. Cognitive reserve hypothesis: Pittsburgh Compound B and fluorodeoxyglucose positron emission tomography in relation to education in mild Alzheimer's disease. Ann Neurol 2008; 63:112-8.
17. Singapore Department of Statistics. Singapore Population Census 2000. [online] Available at: www.singstat.gov.sg/pubn/popn/cop2000admin.pdf. Accessed June 4, 2012.
18. Nasreddine ZS, Phillips NA, Bédirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc 2005; 53:695-9.
19. Randolph C. Repeatable Battery for the Assessment of Neuropsychological Status Manual: The Psychological Corporation. San Antonio: The Psychological Corporation, 1998.