Unconditional and Conditional Standards Using Cognitive Function Curves for the Modified Mini-Mental State Exam: Cross-Sectional and Longitudinal Analyses in Older Chinese Adults in Singapore

Yin Bun Cheung, Ph.D., Ying Xu, Ph.D., Lei Feng, Ph.D., Liang Feng, Ph.D., Ma Shwe Zin Nyunt, Ph.D., Mei Sian Chong, M.B.B.S., F.R.C.P.(Edin.), Wee Shiong Lim, M.Med. (Int.Med.), M.H.P.Ed., Tih Shih Lee, M.D., Philip Yap, M.R.C.P., Keng Bee Yap, F.R.C.P.(Edin.), Tze Pin Ng, M.D.

Objective: *The conventional practice of assessing cognitive status and monitoring change over time in older adults using normative values of the Mini-Mental State Exam (MMSE) based on age bands is imprecise. Moreover, population-based normative data on changes in MMSE score over time are scarce and crude because they do not include age- and education-specific norms. This study aims to develop unconditional standards for assessing current cognitive status and conditional standards that take prior MMSE score into account for assessing longitudinal change, with percentile curves as smooth functions of age.* **Methods:** *Cross-sectional and longitudinal data of a modified version of the MMSE for 2,026 older Chinese adults from the Singapore Longitudinal Aging Study, aged 55–84, in Singapore were used to estimate quantile regression coefficients and create unconditional standards and conditional standards.* **Results:** *We presented MMSE percentile curves as a smooth function of age in education strata, for unconditional and conditional standards, based on quantile regression coefficient estimates. We found the 5th and 10th percentiles were more strongly associated with age and education than were higher percentiles. Model diagnostics demonstrated the accuracy of the standards.* **Conclusion:** *The development and use of unconditional and conditional standards should facilitate cognitive assessment in clinical practice and deserve further studies.* (Am J Geriatr Psychiatry 2014; ■:■–■)

Received May 1, 2014; revised August 10, 2014; accepted August 11, 2014. From the Centre for Quantitative Medicine (YBC, YX) and Neuroscience and Behavioral Disorders Program (TSL), Duke-National University of Singapore Graduate Medical School, Singapore; Department of International Health (YBC), University of Tampere, Finland; Gerontology Research Programme, Department of Psychological Medicine (Lei Feng, Liang Feng, MSZN, TPN), Yong Loo Lin School of Medicine, National University of Singapore, Singapore; Institute of Geriatrics and Active Ageing and Department of Geriatric Medicine (MSC, WSL), Tan Tock Seng Hospital, Singapore; Department of Geriatric Medicine (PY), Khoo Teck Puat Hospital, Singapore; and Department of Geriatric Medicine (KBY), Alexandra Hospital, Singapore. Send correspondence and reprint requests to Tze Pin Ng, M.D., Gerontology Research Programme, Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore. e-mail: pcmngtp@nus.edu.sg

Supplemental digit content is available for this article in the HTML and PDF versions of this article on the journal's Web site (www.ajgponline.org).

http://dx.doi.org/10.1016/j.jagp.2014.08.008

Key Words: Cognitive function, cognitive impairment, Mini-Mental State Exam, norms

INTRODUCTION

The Mini-Mental State Exam (MMSE)[1] is the most widely used screening instrument to assess the level of cognitive functioning in older adults, monitor cognitive changes over time, and assess the effects of interventions on cognitive function. Performance on the MMSE is influenced by age and education, with scores decreasing with older age and lower levels of education.[2] Currently, the development of standards for classifying patients on their level of cognitive function takes the form of normative data and cut-offs for MMSE that are stratified by age and education.[3–5] The conventional practice is to use age bands instead of age as a continuous variable, but this has limitations and disadvantages. If the age bands are, for example, 50–59, 60–69, and so on, the normative value for a 60-year-old person is the same as that for a 69-year-old person, despite a difference of 9 years, and is different from that for a 59-year-old person despite only a 1-year difference in age. As such, the use of normative values stratified by age bands increases the likelihood of misclassifying patients on their cognitive functioning status. The use of age as a continuous variable in the development of standards is more principled and precise. Such methodology has long been the practice in monitoring fetal and child growth. Smooth child growth curves (e.g., gender-specific weight-for-age and length-for-age percentile curves) are widely used as standards for child growth monitoring. The development of cognitive function standards with age as a continuous variable in aging studies is very recent.[6]

To monitor changes in MMSE cognitive performance over time in individual patients, individual changes in MMSE test scores also need to be compared against a normative standard. There are very few published normative values of MMSE change based on a large population of cognitively normal older adults. In most studies, normative change data are limited to crude "ballpark" figures (typically two points or more of MMSE drop annually), which generally ignore younger or older patient age and do not present age- and education-specific change norms (e.g., that in the LEILA 75+ Study).[7] The German Study on Ageing, Cognition and Dementia in Primary Care Patients[8] used a sample of 1,090 cognitively healthy individuals, aged 75 years and older, assessed at 1.5-year intervals over a period of 4.5 years using the MMSE and provided age- and education-specific MMSE change norms based on reliable change index methods to interpret cognitive changes in older age groups. Across different age and education subgroups, changes from at least two up to three points indicated significant (i.e., reliable) changes in MMSE test scores at the 90% confidence level. This approach requires the calculation of reliable change indices for individual patients to interpret changes in MMSE test scores that are not due to measurement error, practice effects, or regression-to-the-mean. The alternative approach of developing smooth growth curves for use as standards in monitoring cognitive decline in older adults has not been reported.

Most standards in use are "unconditional standards" in that they only consider performance at one point in time, without considering a previous level of performance. A person with an MMSE score at the 50th percentile 2 years ago and 10th percentile now is considered normal at both time points. However, considering the person had a much higher percentile position 2 years ago, one may suspect that he or she may have been experiencing the onset of a cognitive disorder and deserves further attention. Such a longitudinal perspective requires the "conditional standards,"[9,10] which are exemplified by longitudinal fetal and postnatal growth curves used in the monitoring of fetal and child growth but have so far not appeared in the literature on cognitive function in the elderly. This study aims to provide age- and education-specific unconditional and conditional standards for a modified version of the MMSE[11–13] for 55- to 84-year-old ethnic Chinese in Singapore.