Population-Based Norms for the Mini-Mental State Examination by Age and Educational Level

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Objective.—To report the distribution of Mini-Mental State Examination (MMSE) scores by age and educational level.

Design.—National Institute of Mental Health Epidemiologic Catchment Area Program surveys conducted between 1980 and 1984.

Setting.—Community populations in New Haven, Conn; Baltimore, Md; St Louis, Mo; Durham, NC; and Los Angeles, Calif.

Participants.—A total of 18 056 adult participants selected by probability sampling within census tracts and households.

Main Outcome Measures.—Summary scores for the MMSE are given in the form of mean, median, and percentile distributions specific for age and educational level.

Results.—The MMSE scores were related to both age and educational level. There was an inverse relationship between MMSE scores and age, ranging from a median of 29 for those 18 to 24 years of age, to 25 for individuals 80 years of age and older. The median MMSE score was 29 for individuals with at least 9 years of schooling, 26 for those with 5 to 8 years of schooling, and 22 for those with 0 to 4 years of schooling.

Conclusions.—Cognitive performance as measured by the MMSE varies within the population by age and education. The cause of this variation has yet to be determined. Mini-Mental State Examination scores should be used to identify current cognitive difficulties and not to make formal diagnoses. The results presented should prove to be useful to clinicians who wish to compare an individual patient's MMSE scores with a population reference group and to researchers making plans for new studies in which cognitive status is a variable of interest.

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SINCE its introduction in 1975, the Mini-Mental State Examination (MMSE) has become a widely used method for assessing cognitive mental status both in clinical practice and in research.[1-4] The evaluation of cognitive functioning is important in clinical settings because of the known high prevalence of cognitive impairment in medical patients.[5,6] As a clinical instrument, the MMSE has been used to detect impairment, follow the course of an illness, and monitor response to treatment.[1-4] As a research tool, it has been used to screen for cognitive disorders in epidemiologic studies of community dwelling and institutionalized populations[7-11] and to follow cognitive change in clinical trials.[12-16]

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While the MMSE has limited specificity with respect to individual clinical syndromes, it is a brief, standardized method to grade patients' cognitive mental status. It assesses orientation, attention, immediate and short-term recall, language, and the ability to follow simple verbal and written commands (Fig 1). It provides a total score that places the individual on a scale of cognitive function.

The MMSE has been used within different cultural and ethnic subgroups and has been translated into several different languages.[10,11,17,18] A modified version has been used successfully with the hearing impaired.[19] Furthermore, the MMSE has been used as a method of predicting intellectual level,[20] as well as predicting attrition of elderly subjects from a longitudinal study.[21] High correlation with other, more comprehensive standardized instruments for the assessment of cognitive function, such as the Wechsler Adult Intelligence Scale,[4] and other screening tests, such as the Modified Blessed Test, has been reported.[22,23] Scores correlate with several physiological measures (ie, association with computed tomographic abnormality[24,25] and cerebral ventricular size,[26] perfusion deficits on single-photon emission computed tomographic scan,[27] and long-latency event-related potentials[28]). Using a cutoff score of 23, the sensitivity and specificity of the MMSE has been reported to be 87% and 82%, respectively, for detecting delirium or dementia in hospitalized patients.[29] It is a screening test, however, and does not identify specific disorders.[29]

Prior reports from the National Institute of Mental Health Epidemiologic Catchment Area (ECA) Program have given prevalence rates for levels of cog-

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nitive impairment using the MMSE.[11,29,30] Individuals aged 55 to 74 years were found to have 1.4 to 2.5 times the prevalence of severe cognitive impairment (MMSE score, 17 or lower) as compared with those aged 35 to 54 years.[11] In addition, scores of 17 or lower were more common among adults with 8 years of schooling or less.[11] Although no difference in prevalence was found by sex, differences were reported across race/ethnicity groups. Blacks were found to have higher prevalence rates of severe impairment as compared with either whites or Hispanics.[11] Recently, Bleecker et al[31] reported age-specific MMSE values in 194 healthy men and women aged 40 to 89 years, with 7 to 21 years of schooling. Total score was correlated with age but not with education. Although some prior reports of prevalence rates have shown the association of age and educational level with total MMSE score, the information has been difficult to apply to the clinical arena, where there often is a need to evaluate a score obtained for individual patients of different age and education levels. However, there have been no published MMSE scores by age and education based on large representative community samples, which would allow clinicians to place patients' scores in the context of their communities.

Percentile points, commonly obtained by ranking the data values in ascending order from lowest to highest,[32,33] provide an approach that can be used by clinicians to evaluate individual patients against the distribution of scores in a particular population or subsample thereof,[32,34] which is done for children's growth charts that are gender and age specific. If we examined a 24-year-old high school graduate who received a score of 25 on the MMSE, we might ask: "How does this score compare with expected values based on samples of other 24-year-old high school graduates?" Gauged against a percentile distribution, this score can tell whether the patient is at the median (50% with better scores and 50% with worse scores) or within the interquartile range (scores from 25% to 75%) or below the fifth percentile (more than 95% score better). As discussed by Feinstein,[32,35] the percentile technique is simple to use and appropriate for data with nongaussian distributions, as we have found with the MMSE.[3]

It is in this sense of a comparative distribution that we refer to these findings as "population-based norms," without any implication that all persons are free of disease that might cause impairment in cognitive functions. This approach to the definition of population norms is similar to that used for height, weight, and blood pressure nomograms, where both diseased and nondiseased persons are represented in the reported distributions.

Several studies indicate that the score obtained on the MMSE reflects numerous pathological and etiological conditions and so does not provide a specific categorical diagnosis. Patients with the diagnosis of dementia, delirium, or mental retardation often obtain low scores as do individuals with schizophrenia and depression. Since all of these categories will be present in varying proportions depending on the time and place of testing, the probability of a given score will vary with the distribution of pathological states in that population. Given these differences, what are we to expect for an average or normal MMSE score? One definition of a normal score can be that which was obtained by 95% of the population (fifth percentile).[36] Another definition of normal based on the gaussian model would be the range of scores that fall between 2 SDs of the mean.[32] Those scoring lower for either definition would be the tail of the distribution of scores in the sample studied. To provide a benchmark for these values, we have analyzed MMSE scores for 18 056 individuals in five sites across the United States.

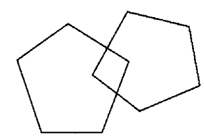
The intent of this article is to report the distribution of the MMSE by age and education based on an assessment of individuals surveyed in the National Institute of Mental Health ECA Program. The reported samples were selected to be representative of the five communities surveyed and include individuals regardless of their physical or mental health status. To the extent that a clinician's patients might be similar to members of this representative population sample, their scores can be compared with those produced by this study.

METHODS

Sampling and Measurement

Between 1980 and 1984, collaborators in the National Institute of Mental Health ECA Program recruited 18 571 adult participants after selection by probability sampling within census tracts and households in five metropolitan areas: New Haven, Conn; Baltimore, Md; St Louis, Mo; Durham, NC; and Los Angeles, Calif. Staff administered the Diagnostic Interview Schedule soon after sampling. The mean survey participation was 76% (range, 68% to 79%). All study data were gathered with standardized interview methods. Neither subjects nor interviewers were aware

	Score	Points
Orientation		
1. What is the		
Year?	___	1
Season?	___	1
Date?	___	1
Day?	___	1
Month?	___	1
2. Where are we		
State?	___	1
County?	___	1
Town/city?	___	1
Floor?	___	1
Address/name of building?	___	1
Registration		
3. Name three objects, taking one second to say each. Then ask the patient all three after you have said them. Repeat the answers until the patient learns all three.	___	3
Attention and Calculation		
4. Serial sevens. Give one point for each correct answer. Stop after five answers. Alternative: Spell *world* backward.	___	5
Recall		
5. Ask for names of three objects learned in question 3. Give one point for each correct answer.	___	3
Language		
6. Point to a pencil and a watch. Have the patient name them as you point.	___	2
7. Have the patient repeat "No ifs, ands, or buts."	___	1
8. Have the patient follow a three-stage command: "Take the paper in your right hand. Fold the paper in half. Put the paper on the floor."	___	3
9. Have the patient read and obey the following: "Close your eyes."	___	1
10. Have the patient write a sentence of his or her own choice. (The sentence should contain a subject and an object and should make sense. Ignore spelling errors when scoring.)	___	1
11. Enlarge the design printed below to 1 to 5 cm per side and have the patient copy it. (Give one point if all the sides and angles are preserved and if the intersecting sides form a quadrangle.)	___	1



Total	______	**30**

Fig 1.—The clinical version of the Mini-Mental State Examination. A copy of the field survey has been published.[3] For institutionalized or hospitalized patients, the name of the building was asked in question 2.

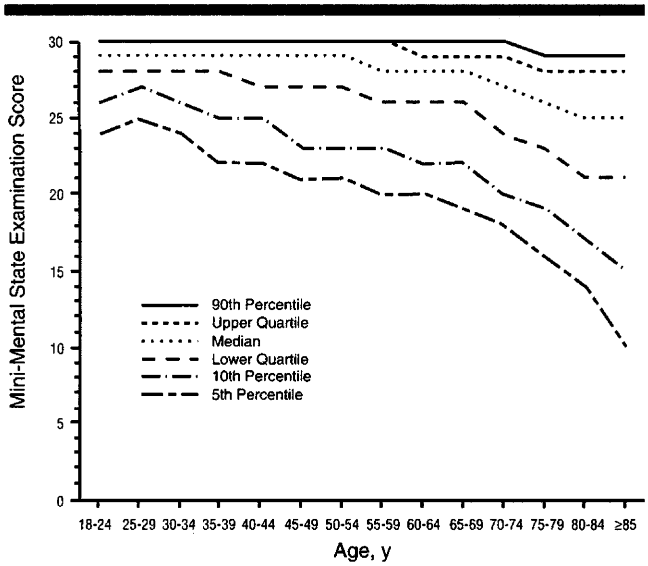


Fig 2.—Mini-Mental State Examination score by age and selected percentiles. Data from the Epidemiologic Catchment Area surveys, 1980 to 1984, with weights based on the 1980 US population distributions for age, sex, and race.

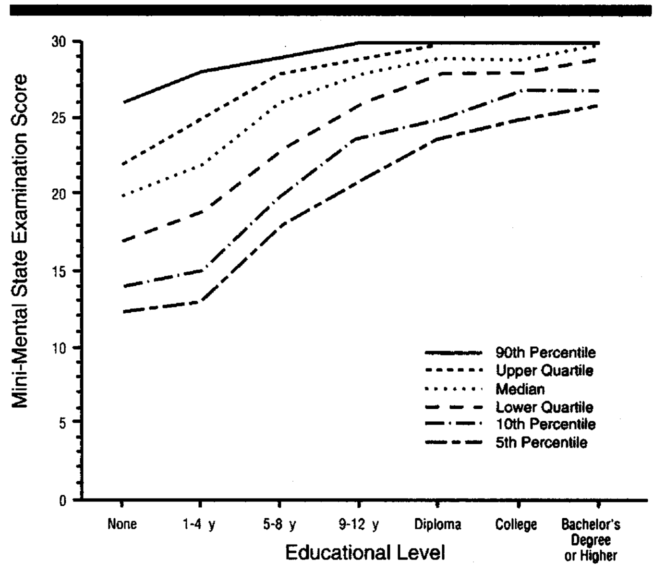


Fig 3.—Mini-Mental State Examination score by educational level and selected percentiles. Data from the Epidemiologic Catchment Area surveys, 1980 to 1984, with weights based on the 1980 US population distributions for age, sex, and race.

that the age and education distribution of the MMSE would be evaluated specifically. Sampled individuals underwent a comprehensive interview to examine symptoms associated with psychiatric disorders, patterns of substance use, and utilization of health services, as well as demographic factors. The MMSE was included as a part of the Diagnostic Interview Schedule in order to assess cognitive functioning. A detailed discussion of the history, sampling methods, and instruments used in this survey, as well as a description of the specific scoring techniques used for the MMSE has been reported elsewhere.[37-41]

Of the 18 571 adult participants originally surveyed in the ECA household surveys, 18 056 were included for this analysis. A total of 515 individuals with missing data were excluded. Study participants were administered the MMSE field survey form,[3,11] which includes two substitutions from the original MMSE (Fig 1). Instead of being asked for the county in which they were currently located, subjects were asked for the names of two main streets nearby. In addition, participants were asked to perform both the serial sevens (asked to subtract by sevens from 100) and also asked to spell *world* backward.[3,11] The question that led to the highest total MMSE score was used. The MMSE score was calculated by summing the correct responses to MMSE items to yield a total score. The test score falls in a range from the lowest possible (0) to the highest (30). More detailed descriptions of the administration of the MMSE have been published elsewhere.[1,3,29]

The ECA sample included adults aged 18 years and older. The age variable used in this study's analyses was categorized according to the following intervals of years: 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, and up to 85 and older. Education was categorized by years of schooling completed, and each respondent was assigned to the category corresponding to the highest grade achieved.

Correlations, Percentiles, and Weighting

Spearman's rank correlation coefficients were calculated to assess the relationship between MMSE scores and our variables of interest, age, and years of schooling.[42] The weighted percentile points were obtained using the univariate procedure of the SAS statistical computer program,[42] assigning averaged ranked scores for tied data values. Weighted quartiles were obtained in the same manner. The lower, median, and upper quartiles corresponded to the 25th, 50th, and 75th percentiles, respectively. Whereas others have examined potential variation in MMSE scores across the five individual ECA sites,[11] this study has involved use of all available data from the ECA household samples, and a standardization and weighting procedure was used to make the samples' age, sex, and race distributions comparable and balanced with the corresponding age, sex, and race distributions for the United States, as determined by the 1980 census.[43] This procedure has been used widely in analyses of the five-site ECA data, including both published books[11,38] and scientific articles.[44,45] Nonetheless, a separate analysis (not presented) also was carried out on the unweighted sample. No appreciable differences were found when the weighted and unweighted results were compared.

RESULTS

In this study, we found that bivariate correlations between MMSE score with both age and years of schooling proved to be significant (for age, the Spearman coefficient was −.38 and $P<.001$; for years of schooling, it was .50 and $P<.001$). Figures 2 and 3 present the age and educational distributions for the total MMSE score among adult participants in the ECA household surveys. Consistent with increasing incidence of dementia and other cognitive impairments with age,[40,46] the total MMSE score was found to decline with age (Fig 2). That is, scanning upward through the age strata, one finds a steady and consistent decline in score across all percentiles. The distribution of the MMSE scores also demonstrated a wider range of score with increasing age. For example, 95% of adults between the ages of 18 and 45 years had a score of at least 22, with a median score of 29. In contrast, for adults aged 65 to 69 years the median score was 28, but the range of scores for 95% of the population was much wider. The figure also illustrates the skewed nature of the distribution of the MMSE scores, with heavy clustering at the higher scores.

The MMSE scores also varied with educational level (Fig 3). Across increasing

Mini-Mental State Examination Score by Age and Educational Level, Number of Participants, Mean, SD, and Selected Percentiles*

	Age, y														
Educational Level	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85	Total
0 to 4 y															
n	17	23	41	33	36	28	34	49	88	126	139	112	105	61	**892**
Mean	22	25	25	23	23	23	23	22	23	22	22	21	20	19	22
SD	2.9	2.0	2.4	2.5	2.6	3.7	2.6	2.7	1.9	1.9	1.7	2.0	2.2	2.9	2.3
Lower quartile	21	23	23	20	20	20	20	20	19	19	19	18	16	15	19
Median	23	25	26	24	23	23	22	22	22	22	21	21	19	20	22
Upper quartile	25	27	28	27	27	26	25	26	26	25	24	24	23	23	25
5 to 8 y															
n	94	83	74	101	100	121	154	208	310	633	533	437	241	134	**3223**
Mean	27	27	26	26	27	26	27	26	26	26	26	25	25	23	26
SD	2.7	2.5	1.8	2.8	1.8	2.5	2.4	2.9	2.3	1.7	1.8	2.1	1.9	3.3	2.2
Lower quartile	24	25	24	23	25	24	25	25	24	24	24	22	22	21	23
Median	28	27	26	27	27	27	27	27	27	27	26	26	25	24	26
Upper quartile	29	29	28	29	29	29	29	29	29	29	28	28	27	27	28
9 to 12 y or high school diploma															
n	1326	958	822	668	489	423	462	525	626	814	550	315	163	99	**8240**
Mean	29	29	29	28	28	28	28	28	28	28	27	27	25	26	28
SD	2.2	1.3	1.3	1.8	1.9	2.4	2.2	2.2	1.7	1.4	1.6	1.5	2.3	2.0	1.9
Lower quartile	28	28	28	28	28	27	27	27	27	27	26	25	23	23	27
Median	29	29	29	29	29	29	29	29	28	28	28	27	26	26	29
Upper quartile	30	30	30	30	30	30	30	30	30	29	29	29	28	28	30
College experience or higher degree															
n	783	1012	989	641	354	259	220	231	270	358	255	181	96	52	**5701**
Mean	29	29	29	29	29	29	29	29	29	29	28	28	27	27	29
SD	1.3	0.9	1.0	1.0	1.7	1.6	1.9	1.5	1.3	1.0	1.6	1.6	0.9	1.3	1.3
Lower quartile	29	29	29	29	29	29	28	28	28	28	27	27	26	25	29
Median	30	30	30	30	30	30	30	29	29	29	29	28	28	28	29
Upper quartile	30	30	30	30	30	30	30	30	30	30	29	29	29	29	30
Total, n	**2220**	**2076**	**1926**	**1443**	**979**	**831**	**870**	**1013**	**1294**	**1931**	**1477**	**1045**	**605**	**346**	**18 056**
Mean	29	29	29	29	28	28	28	28	28	27	27	26	25	24	28
SD	2.0	1.3	1.3	1.8	2.0	2.5	2.4	2.5	2.0	1.6	1.8	2.1	2.2	2.9	2.0
Lower quartile	28	28	28	28	27	27	27	26	26	26	24	23	21	21	27
Median	29	29	29	29	29	29	29	29	28	28	27	26	25	25	29
Upper quartile	30	30	30	30	30	30	30	30	29	29	29	28	28	28	30

*Data from the Epidemiologic Catchment Area household surveys in New Haven, Conn; Baltimore, Md; St Louis, Mo; Durham, NC; and Los Angeles, Calif, between 1980 and 1984. The data are weighted based on the 1980 US population census by age, sex, and race.

levels of educational achievement, the MMSE score increased, and the range of scores narrowed. Individuals who reported no formal schooling demonstrated the lowest scores and the widest range.

These general patterns of distribution in the MMSE score persisted when the age and education distributions were combined (Table). The greatest degree of variability occurred in the lowest educational groups at the oldest ages. The median MMSE score was 29 for those with at least 9 years of schooling, 26 for those with 5 to 8 years of schooling, and 22 for those with 0 to 4 years of schooling.

COMMENT

This study presents MMSE scores for a population-based sample of 18 056 adults drawn from five communities in the United States. This large sample is unique for the evaluation of this type of cognitive test. The data represent the distribution of MMSE scores by age and educational level as they exist within these communities. We therefore refer to these values as "norms," in line with one of Feinstein's[47] definitions of "range of normal." In this study, as in others,[11,29-31,48] we found that age and level of education were associated with MMSE scores obtained in a community-based household survey. The MMSE scores were lower for the oldest age groups and for those with fewer years of schooling. Although the prevalence of cognitive disorders in general, and Alzheimer's disease in particular, has been found to increase with age,[49] the data presented here illustrate that cognitive impairment as evidenced by performance on the MMSE is not only related to age but is also clearly related to educational level. For example, even within a specific age stratum, the MMSE varied appreciably between educational groups: from a median score of 20 among individuals aged 85 years and older with the lowest educational level (0 to 4 years of education) to a median score of 28 for the highest educational level (college level experience or higher).

The MMSE scores were not distributed normally, and thus, the use of the assumptions of normal theory do not apply. However, several studies of patients that ignored this caveat found an SD of 2 to 3 points. In this sample, we found that individuals at the 25th percentile (lower quartile) with 0 to 4 years of education scored 19 and below, while those at the 25th percentile with college education experience scored 29 and below. The median score ranged from 22 to 29 in these educational groups. Thus, we found the scores to be more variable in those with low education than in those with high education. Several explanations for this difference in variability are possible. Some have argued that there needs to be an adjustment of MMSE scores,[48,50,51] because individuals with low levels of education might not be able to take tests well in spite of their cognitive capacity. If this were true, then the test should be biased in the low-education group. Jorm et al[52] suggested that this is not the case. Furthermore, Bassett and Folstein[53] showed that low-education individuals with low MMSE scores also were less able to perform tasks of everyday living, suggesting that these individuals might indeed be more cognitively impaired. The lower degree of variability in the high-education group may also reflect a type of ceiling effect or a lower sensitivity of the MMSE for detecting cognitive impairment in these individuals. Another explanation is that the low-education group is subject to a wide deviation in score because there is a greater variation in pathological conditions in this group. This interpretation is consistent with the increased prevalence of many diseases among low educational and lower socioeconomic class individuals. Still another explanation is that there is an increased prevalence of developmental disorders within this group. Finally, greater variability in the lower education group may indicate a greater prevalence of both developmental and disease states or a combination of any or all of these possibilities.

The interpretation of performance on the MMSE clearly depends on the definition of normal and abnormal, the context for which the examination is being given, the relationship to prior levels of function, and whether diagnostic and therapeutic interventions are implied and anticipated. As with all clinical test data for which reference standards are available, clinical judgment is required to weigh the possibilities for error in the individual test score and the possible explanations of results substantially lower or higher than expected values.

The least complicated way for a clinician to use these results is to locate an individual patient's MMSE score within the percentile distribution shown for that patient's age and educational level. Hence, for an 82-year-old with a high school diploma, 50% of the corresponding age-education group in the community were above an MMSE score of 26, and 50% were below 26. However, a 25-year-old high school graduate with a score of 26 would be below the 25th percentile (at least 75% scoring better).

The use of percentiles as a way of evaluating the range of scores for specific age and educational categories gives the clinician and researcher a method of comparison that takes into account these factors. To the extent that age, education, and related variables are determinants of cognitive impairment, or of the clinical syndromes having cognitive impairment as a cardinal feature, it can be a mistake to adjust MMSE or other cognitive impairment scores for age or for levels of education as discussed by Berkman.[54]

Several limitations in our report merit attention. First, the ECA population sample was affected to some extent by nonresponse of designated subjects, and despite statistical maneuvers to bring the age, sex, and race distributions into balance with those of the United States as a whole, these results have unknown generalizability, an issue best examined through systematic replication of these results. Second, the measurement plan in the ECA had minor variations across sites in the determination of correct responses for complex MMSE questions, which seem to have induced a small and apparently negligible amount of variation across sites.[11,44] Third, it should be noted that the MMSE scores obtained in the ECA were based on either the response to serial sevens or spelling *world* backward, whichever yielded the higher total score. This is a procedure that differs slightly from the original MMSE scoring rules[1] but is identical to the procedure used in prior research to evaluate the MMSE sensitivity and specificity and to estimate prevalence of cognitive impairment in the community.[3,11,29] Fourth, because the MMSE was administered to subjects in their homes, it is possible that their scores might be higher than would be expected in an office setting. Fifth, some of the age-education strata had small numbers and this might mean that for these relationships, the findings might be less reliable. Finally, without the benefit of clinical evaluations on the survey participants in this study, we were unable to correlate scores on the MMSE with a clinical diagnosis. This also prevented us from evaluating any change in the distribution of MMSE scores, which might have resulted from the exclusion of individuals with cognitive disorders.

Notwithstanding such limitations, the distributions presented here provide usable reference values for clinicians or investigators who use the MMSE to assess the cognitive functioning of their patients or study subjects. In addition, the study highlights a need for more research on clinically useful cutoff values for the MMSE and use of the MMSE as an indication of various levels of cognitive impairment. The relationships of MMSE scores with other sociodemographic characteristics, such as gender, race/ethnicity, occupation, income, and geographic residence, are other areas for further investigation.

In summary, this article examines the distribution of age and educational level with the MMSE score and presents a useful method for evaluating an individual's MMSE score against reference standards based on a recent, large-scale population study.

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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;12:189-198.
2. Teng EL, Chui HC, Schneider LS, Metzger LE. Alzheimer's dementia: performance on the Mini-Mental State Examination. *J Consult Clin Psychol.* 1987;55:96-100.
3. Folstein M, Anthony JC, Parhad I, Duffy B, Gruenberg EM. The meaning of cognitive impairment in the elderly. *J Am Geriatr Soc.* 1985;33: 228-235.
4. Horton AM, Slone DG, Shapiro S. Neuropsychometric correlates of the Mini-Mental State Examination: preliminary data. *Percept Mot Skills.* 1987;65:64-66.
5. Knights EB, Folstein MF. Unsuspected emotional and cognitive disturbance in medical patients. *Ann Intern Med.* 1977;87:723-724.
6. Roca RP, Klein LE, Kirby SM, et al. Recognition of dementia among medical patients. *Arch Intern Med.* 1984;144:73-75.
7. Rovner BW, Kafonek S, Filipp L, Lucas MJ, Folstein MF. Prevalence of mental illness in a community nursing home. *Am J Psychiatry.* 1986;143: 1446-1449.
8. Steele C, Rovner B, Chase GA, Folstein M. Psychiatric symptoms and nursing home placement of patients with Alzheimer's disease. *Am J Psychiatry.* 1990;147:1049-1051.
9. Fried LP, Borhani NO, Enright P, et al. The Cardiovascular Health Study: design and rationale. *Ann Epidemiol.* 1991;1:263-276.
10. Li G, Shen YC, Chen CH, Zhao YW, Li SR, Lu M. An epidemiological survey of age-related dementia in an urban area of Beijing. *Acta Psychiatr Scand.* 1989;79:557-563.
11. George LK, Landerman R, Blazer DG, Anthony JC. Cognitive impairment. In: Robins LN, Regier DA, eds. *Psychiatric Disorders in America: The Epidemiologic Catchment Area Study.* New York, NY: The Free Press; 1991:291-327.
12. Gauthier S, Bouchard R, Lamontagne A, et al. Tetrahydroaminoacridine-lecithin combination treatment in patients with intermediate-stage Alzheimer's disease: results of a Canadian double-blind, crossover, multicenter study. *N Engl J Med.* 1990;322:1272-1276.
13. Chatellier G, Lacomblez L. Tacrine (tetrahydroaminoacridine; THA) and lecithin in senile dementia of the Alzheimer type: a multicentre trial. *BMJ.* 1990;300:495-499.
14. Devanand DP, Sackeim HA, Brown RP, Mayeux R. A pilot study of haloperidol treatment of psychosis and behavioral disturbance in Alzheimer's disease. *Arch Neurol.* 1989;46:854-857.
15. Indaco A, Carrieri PB. Amitriptyline in the treatment of headache in patients with Parkinson's

disease: a double-blind placebo-controlled study. *Neurology.* 1988;38:1720-1722.
16. Balestreri R, Fontana L, Astengo F. A double-blind placebo controlled evaluation of the safety and efficacy of vinpocetine in the treatment of patients with chronic vascular senile cerebral dysfunction. *J Am Geriatr Soc.* 1987;35:425-430.
17. Bird HR, Canino G, Stipec MR, Shrout P. Use of the Mini-Mental State Examination in a probability sample of a Hispanic population. *J Nerv Ment Dis.* 1987;175:731-737.
18. Salmon DP, Riekkinen PJ, Katzman R, Zhang M, Jin H, Yu E. Cross-cultural studies of dementia: a comparison of Mini-Mental State Examination performance in Finland and China. *Arch Neurol.* 1989;46:769-772.
19. Uhlmann RF, Larson EB, Rees TS, Koepsell TD, Duckert LG. Relationship of hearing impairment to dementia and cognitive dysfunction in older adults. *JAMA.* 1989;261:1916-1919.
20. Farber JF, Schmitt FA, Logue PE. Predicting intellectual level from the Mini-Mental State Examination. *J Am Geriatr Soc.* 1988;36:509-510.
21. Liu IY, Anthony JC. Using the 'Mini-Mental State' Examination to predict elderly subjects' completion of a follow-up interview. *Am J Epidemiol.* 1989;130:416-422.
22. Fillenbaum GG, Heyman A, Wilkinson WE, Haynes CS. Comparison of two screening tests in Alzheimer's disease: the correlation and reliability of the Mini-Mental State Examination and the Modified Blessed Test. *Arch Neurol.* 1987;44:924-927.
23. Zillmer EA, Fowler PC, Gutnick HN, Becker E. Comparison of two cognitive bedside screening instruments in nursing home residents: a factor analytic study. *J Gerontol.* 1990;45:P69-P74.
24. Colohan H, O'Callaghan E, Larkin C, Waddington JL. An evaluation of cranial CT scanning in clinical psychiatry. *Ir J Med Sci.* 1989;158:178-181.
25. Tsai L, Tsuang MT. The Mini-Mental State Test and computerized tomography. *Am J Psychiatry.* 1979;136:436-439.
26. Pearlson GD, Tune LE. Cerebral ventricular size and cerebrospinal fluid acetylcholinesterase levels in senile dementia of the Alzheimer type. *Psychiatry Res.* 1986;17:23-29.
27. DeKosky ST, Shih WJ, Schmitt FA, Coupal J, Kirkpatrick C. Assessing utility of single photon emission computed tomography (SPECT) scan in Alzheimer disease: correlation with cognitive severity. *Alzheimer Dis Assoc Disord.* 1990;4:14-23.
28. Finley WW, Faux SF, Hutcheson J, Amstutz L. Long-latency event-related potentials in the evaluation of cognitive function in children. *Neurology.* 1985;35:323-327.
29. Anthony JC, LeResche L, Niaz U, Von Korff MR, Folstein MF. Limits of the 'Mini-Mental State' as a screening test for dementia and delirium among hospital patients. *Psychol Med.* 1982;12:397-408.
30. Holzer CE, Tischler GL, Leaf PJ, Myers JK. An epidemiologic assessment of cognitive impairment in a community population. In: Greenley JR, ed. *Research in Community and Mental Health.* Greenwich, Conn: JAI Press; 1984;4:3-32.
31. Bleecker ML, Bolla-Wilson K, Kawas C, Agnew J. Age-specific norms for the Mini-Mental State Exam. *Neurology.* 1988;38:1565-1568.
32. Feinstein AR. *Clinical Epidemiology.* Philadelphia, Pa: WB Saunders Co; 1985.
33. Armitage P, Berry G. *Statistical Methods in Medical Research.* 2nd ed. Boston, Mass: Blackwell Scientific Publications Inc; 1987.
34. Elveback LR, Guillier CL, Keating FR. Health, normality, and the ghost of Gauss. *JAMA.* 1970; 211:69-75.
35. Feinstein AR. Clinical biostatistics, XXV: a survey of the statistical procedures in general medical journals. *Clin Pharmacol Ther.* 1974;15:97-107.
36. Murphy EA. *Biostatistics in Medicine.* Baltimore, Md: Johns Hopkins University Press; 1982.
37. Robins LN, Helzer JE, Croughan J, Ratcliff KS. The National Institute of Mental Health Diagnostic Interview Schedule: its history, characteristics, and validity. *Arch Gen Psychiatry.* 1981; 38:381-389.
38. Eaton WW, Kessler LG, eds. *Epidemiologic Field Methods in Psychiatry: The NIMH Epidemiologic Catchment Area Program.* Orlando, Fla: Academic Press Inc; 1985.
39. Anthony JC, Folstein M, Romanoski AJ, et al. Comparison of the lay Diagnostic Interview Schedule and a standardized psychiatric diagnosis: experience in eastern Baltimore. *Arch Gen Psychiatry.* 1985;42:667-675.
40. Eaton WW, Kramer M, Anthony JC, Dryman A, Shapiro S, Locke BZ. The incidence of specific DIS/DSM-III mental disorders: data from the NIMH Epidemiologic Catchment Area Program. *Acta Psychiatr Scand.* 1989;79:163-178.
41. Eaton WW, Kramer M, Anthony JC, Chee EML, Shapiro S. Conceptual and methodological problems in estimation of the incidence of mental disorders from field survey data. In: Cooper B, Helgason T, eds. *Epidemiology and the Prevention of Mental Disorders.* London, England: Routledge; 1989:108-127.
42. SAS Institute Inc. *SAS User's Guide: Statistics, Version 5 Edition.* Cary, NC: SAS Institute Inc; 1985.
43. Leaf PJ, Myers JK, McEvoy LT. Procedures used in the Epidemiologic Catchment Area Study. In: Robins LN, Reiger DA, eds. *Psychiatric Disorders in America: The Epidemiologic Catchment Area Study.* New York, NY: The Free Press; 1991: 11-32.
44. Regier DA, Boyd JH, Burke JD, et al. One-month prevalence of mental disorders in the United States based on five Epidemiologic Catchment Area sites. *Arch Gen Psychiatry.* 1988;45:977-986.
45. Regier DA, Farmer ME, Rae DS, et al. Comorbidity of mental disorders with alcohol and other drug abuse: results from the Epidemiologic Catchment Area (ECA) Study. *JAMA.* 1990;264:2511-2518.
46. Evans DA, Funkenstein HH, Albert MS, et al. Prevalence of Alzheimer's disease in a community population of older persons. *JAMA.* 1989;262:2551-2556.
47. Feinstein AR. *Clinical Biostatistics.* St Louis, Mo: CV Mosby Co; 1977.
48. Magaziner J, Bassett SS, Hebel JR. Predicting performance on the Mini-Mental State Examination. *J Am Geriatr Soc.* 1987;35:996-1000.
49. Folstein MF, Bassett SS, Anthony JC, Romanoski AJ, Nestadt GR. Dementia: case ascertainment in a community survey. *J Gerontol.* 1991;46:M132-M138.
50. O'Connor DW, Pollitt PA, Treasure FP, Brook CPB, Reiss BB. The influence of education, social class, and sex on Mini-Mental State scores. *Psychol Med.* 1989;19:771-776.
51. Kittner SJ, White LR, Farmer ME, et al. Methodological issues in screening for dementia: the problem of education adjustment. *J Chronic Dis.* 1986; 39:163-170.
52. Jorm AF, Scott R, Henderson AS, Kay DWK. Educational level differences on the Mini-Mental State: the role of test bias. *Psychol Med.* 1988;18: 727-731.
53. Bassett SS, Folstein MF. Cognitive impairment and functional disability in the absence of psychiatric diagnosis. *Psychol Med.* 1991;21:77-84.
54. Berkman LF. The association between educational attainment and mental status examinations: of etiologic significance for senile dementias or not? *J Chronic Dis.* 1986;39:171-174.