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NORMS FOR THE MINI-MENTAL STATE EXAMINATION

Adjustment of the cut-off point in population-based studies (evidences from the Bambuí health aging study)

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Abstract – Objective: To estimate the prevalence of cognitive impairment in an elderly population-based cohort, using several Mini-Mental State Examination (MMSE) cut-off points recommended by Brazilian authors and to examine the percentile distribution of MMSE scores in the study population. **Method:** A total of 1558 subjects aged ≥60 years (89.4% of the total), living in the city of Bambuí, MG, completed the MMSE and were included in the present study. **Results:** The estimated prevalences of cognitive impairment varied from 13.2% to 27.0% depending on the cut-off point and agreement varied widely between them (kappa range: 0.38 to 0.88). Cut-off point 13/14 corresponded to the 5th percentile and 21/22 corresponded to the lower quartile of the MMSE score distribution. **Conclusion:** In the absence of comparable cut-off points, percentile distributions are more adequate for population-based studies of elderly with low schooling level.

KEY WORDS: elderly, cognitive symptoms, epidemiology, Brazil.

Normas para o uso do Mini-Exame do Estado Mental: adequação do ponto de corte em estudos populacionais (evidências do Projeto Bambuí)

Resumo – Objetivo: Estimar a prevalência de déficit cognitivo em uma base populacional de idosos, utilizando-se os diferentes pontos de corte do Mini-Exame do Estado Mental (MEEM) recomendados por autores brasileiros e verificar a distribuição em percentis da pontuação do MEEM na população estudada. **Método:** Participaram do estudo 1558 (89,4% do total) indivíduos com idade ≥60 anos residentes na cidade de Bambuí, MG, que foram submetidos ao MEEM. **Resultados:** A prevalência estimada de déficit cognitivo variou de 13,2% a 27,0%, dependendo do ponto de corte utilizado, observando-se grande variação na sua concordância (índices de kappa entre 0,38 e 0,88). O ponto de corte de 13/14 correspondeu ao 5º percentil e o de 21/22, ao quartil inferior da distribuição dos escores do MEEM. **Conclusão:** Na ausência de pontos de corte comparáveis, a distribuição em percentis é mais adequada para estudos de base populacional de idosos com baixa escolaridade.

PALAVRAS-CHAVE: idosos, sintomas cognitivos, epidemiologia, Brasil.

The Mini-mental State Examination (MMSE)[1] is one of the most widely used cognitive screening scales[2], but populations with low schooling level present a worse performance in this test[3,4]. Therefore, several strategies have been proposed in order to minimize the effects of schooling level in the interpretation of results, such as: (1) adjustment of cut-off points according to schooling level[5-8], (2) the use of cut-off points based on the distribution of MMSE scores in the study population[9] and (3) transcultural adaptation[10-12]. In Brazil, the most common approach has been the use of different cut-off points according to schooling level. Bertolucci et al.[5] were the first to suggest this, proposing a cut-off of 12/13 for illiterate subjects, 17/18 for individuals with one to seven years of schooling and 25/26 for those with eight or more years of schooling[5]. Later, other cut-off points were suggested: Almeida[7] recommended 19/20 as the cut-off point for illiterate subjects and 23/24 for elderly with any schooling. Car-

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Appendix. Previous Brazilian studies that recommended cut-off points for the Mini-mental State Examination (MMSE) according to schooling level.

Author (year)	Setting / Study subjects	Age (years)	MMSE cut-off points
Bertolucci et al. (1994)	n=530, most from triage service and few inpatients from a general hospital 55% women	38% 15–50 37% 51–64 25% ≥65	Illiterate: 12/13 1–7 years of schooling: 17/18 ≥8 years of schooling: 25/26
Almeida (1998)	211 geriatric mental health clinic outpatients: 70 with dementia 141 with other mental disorders 69.2% women	≥60 Mean: 69.4	Illiterate: 19/20 Any schooling: 23/24
Caramelli et al. (1999)	Community-based sample 570 illiterate subjects: 62 with dementia 67.7% women	≥65 Mean: 74.7±7.1	Illiterate: 17/18
Lourenço and Veras (2006)	303 geriatric clinic outpatients: 78 with dementia 71.6% women	≥65 Mean: 73±5.3	Illiterate: 18/19 Any schooling: 24/25

amelli et al.[6] suggested a cut-off point of 17/18 for illiterate individuals. More recently, Lourenço et al.[8] recommended 18/19 as the cut-off point for illiterate subjects and 24/25 for those with any schooling level (for further details, see Appendix).

When score distribution is used to establish cut-off points, the most recommended approach is to consider that subjects with scores below the 5th percentile have a high probability of dementia[13,14] and to use the lower quartile as the cut-off for cognitive screening[9,15]. In Brazil, the 5th percentile was used to define the cut-off points in a study of patients aged 15 years or more at a general hospital triage[5]. Another study determined the percentile distribution of MMSE scores of a sample of community-dwelling elders aged 65 to 84 years, with no impairment in activities of daily living[9].

The present study evaluated the MMSE scores of 1558 elderly participants of the Bambuí population-based cohort and had the following objectives: (1) to estimate the prevalence of cognitive impairment, using several cut-off points recommended by Brazilian authors; (2) to estimate the agreement when those cut-off points were used; (3) to examine the percentile distribution of MMSE scores in this population.

METHOD

Study population

The present study was conducted at the baseline of the Bambuí cohort of elderly, a population-based study carried out in Bambuí, a city of approximately 15,000 inhabitants, in the State of Minas Gerais. Participants were identified in a complete census of the city population and all 1742 residents with 60 or more years of age on January 1, 1997, were invited to take part in the study[16]. The cohort baseline included 1606 of those individuals (92%). The 1558 baseline members who answered the MMSE were included in the present study; exclusions were due to refusals (n=48).

Mini-Mental State Examination

The MMSE is an instrument that evaluates cognitive function, widely used in clinical practice and community studies[1]. In the present study, a version in Portuguese of the MMSE was used[11]. In the orientation section, questions about season of the year, hospital and floor were substituted for part of the day, room and address. In the attention and calculation section, serial sevens were replaced by summing by fives from zero and the word "Maria" was to be spelled backwards. These adaptations were made after investigations that established the degree of difficulty of questions of the original version in English[11]. Serial fives were considered for the total MMSE score because more subjects completed those items. The MMSE was administered by interviewers with at least 11 years of schooling who were selected among Bambuí inhabitants. They were trained by a qualified psychiatrist (E. Uchoa) and certified after evaluation of the intra and inter-rater reliabilities.

The Bambuí Health Aging Study was approved by the Ethics Committee of the Oswaldo Cruz Foundation. All participants signed an informed consent.

Statistical analysis

To evaluate agreement beyond chance when different MMSE cut-off points were used, Cohen's Kappa statistic was calculated[17] and interpreted as proposed by Altman: values equal or above 0.81 indicated very good agreement; 0.61–0.80, good agreement; 0.41–0.60, fair; 0.21–0.40 indicated poor agreement and values equal or below 0.20 were considered very poor[18]. The normality

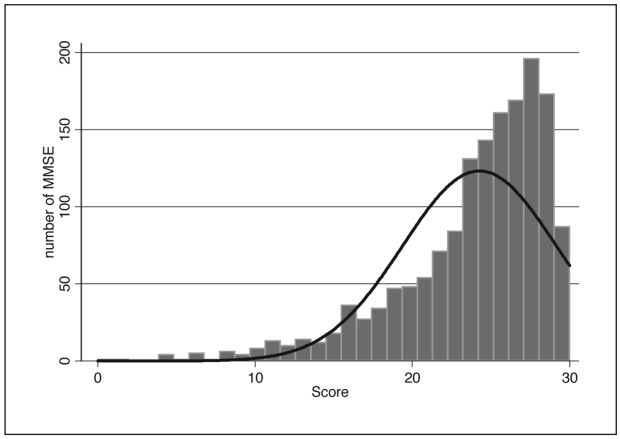

Figure. Mini-mental State Examination score distribution of 1558 elderly participants of the Bambuí cohort baseline.

of score distribution was examined by a test that takes into account the skewness and kurtosis of the curve[19] and both parameters separately. If the distribution is symmetrical (normal) this test presents a value of zero for skewness and 3 for kurtosis. Distributions that are skewed to the left (when the mean is smaller than the median) have negative skewness, while heavy-tailed distributions (peaked) will have kurtosis greater than 3 and light-tailed distributions (flat) will have kurtosis lower than 3. Percentile distributions were also examined. Statistical analyses were performed using Stata 9.2 (College Station, TX, USA).

RESULTS

Among the 1558 subjects (39.7% male and 60.3% female), 518 were 60 to 64 years old. The mean age was 69.0±7.3 years (range: 60–95 years). Low schooling level was predominant: 31.9% had no formal education; 60.1% had 1 to 7 years of schooling, and only 8.0% had 8 or more years of schooling.

Figure presents the distribution of MMSE scores in the study population. The full line shows values that would be expected were the distribution normal. An absence of normality with a pronounced deviation to the right is noted in the score distribution (p<0.001; skewness: –1.43; kurtosis: 5.30).

Table 1. Percentile distribution of scores in the Mini-mental State Examination, and results of the test for normality of the scores for 1558 elderly participants of the Bambuí cohort baseline), according to age.

Percentile	Age (years)		
	Total (n=1558)	60–64 (n=518)	≥65 (n=1040)
5	14	17	13
25 (1st quartile)	22	24	16
50 (median)	26	26.5	25
75 (3rd quartile)	28	28	28
95	30	30	29
	Results of the test for normality of the MMSE score (ordinal data)		
χ^2			
p-value	399.5 <0.0001	202.2 <0.0001	224.4 <0.0001
Skewness	–1.43	–1.82	–1.29
Kurtosis	5.30	7.41	4.70

Skewness: 0; kurtosis: 3 when distribution is normal.

The median MMSE score in the study population was 26. In the group aged 60 to 64 years the median MMSE score was 26.5 while in the group aged 65 or more years it was 25, with a statistically significant difference between age groups (t=6.25; p<0.00001). Scores below the 5th percentile were those below 14 (cut-off 13/14), and scores below the lowest quartile were those below 22 (cut-off 21/22). The corresponding values for the group aged 60–64 years were 17 and 24 and for the group aged ≥65 years were 13 and 16, respectively. MMSE scores presented a non-normal distribution in all situations, i.e., in the total population, in younger and older groups (Table 1).

Table 2 presents the estimated prevalence of cognitive impairment according to different MMSE cut-off points, as well as Cohen's Kappa values obtained comparing those cut-off points. The estimated prevalence of cognitive impairment was 13.2% with the cut-off points proposed by Bertolucci et al.[5] and 22.1%, 23.8% and 27.0% when the cut-

Table 2. Estimated prevalence of cognitive impairment among 1558 elderly of the Bambuí cohort baseline, according to different Mini-mental State Examination cut-off points and Cohen's Kappa between these cut-off points.

	Prevalence	Cohen's Kappa (SD)		
	N (%)	Almeida (1998)	Caramelli et al. (1999)	Lourenço et al. (2006)
Bertolucci et al. (1994)	205 (13.2)	0.38 (0.02)	0.54 (0.03)**	0.40 (0.02)
Almeida (1998)	371 (23.8)		0.73 (0.04)**	0.80 (0.02)
Caramelli et al. (1999)	110 (22.1)*			0.88 (0.04)**
Lourenço et al. (2006)	421 (27.0)			

*Prevalence among illiterate subjects; **Kappa estimated only for illiterate subjects.

Table 3. Percentile distribution of scores in the Mini-Mental State Examination and results of the test for normality of its scores, according to age and schooling level, for 1558 elderly participants of the Bambuí cohort baseline).

Percentile	Illiterate			1 to 7 years of schooling			≥8 years of schooling		
	Total (n=497)	60–64 years (n=121)	≥65 years (n=376)	Total (n=937)	60–64 years (n=352)	≥65 years (n=584)	Total (n=124)	60–64 years (n=44)	≥65 years (n=80)
5	11	13	10	17	20	16	25	25	24.5
25 (1st quartile)	18	19	18	24	25	23.5	27	27	27
50 (median)	22	23	22	26	27	26	28	28	28
75 (3rd quartile)	25	26	25	28	28	28	29	29	29
95	28	29	28	30	30	29	30	30	30
	Results from the test for Normality of the MMSE score (ordinal data)*								
χ^2	46.92	7.95	38.50	91.88	154.86	119.66	65.42	7.73	47.14
p-value	0.009	0.0188	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0210	<0.0001
Skewness	−0.90	−0.67	−0.94	−1.73	−2.36	−1.46	−2.54	−0.96	−2.60
Kurtosis	3.69	2.91	3.74	7.09	12.21	5.35	13.20	3.86	12.31

*Continuous values, Skewness: 0 ; kurtosis: 3 when distribution is normal.

offs proposed by Caramelli et al.[6], Almeida[7] and Lourenço et al.[8] were used, respectively. In regard to the agreement between them, a poor agreement was found in two of the three combinations that evaluated all schooling levels (kappa=0.38 and 0.40) and moderate to excellent agreement in the combinations that considered only illiterate subjects (kappa range 0.54–0.88).

Table 3 presents the percentile distribution of MMSE scores of the study subjects, and the results of the test for normality of its score distribution, according to age and schooling level. The 5th percentile of the score distribution ranged from 11 among illiterate to 17 among those with 1 to 7 years of schooling, and 24 among those with higher schooling level. The distribution of MMSE scores remained non-normal even after stratification by age and schooling level. .

DISCUSSION

The present study is the first to examine the performance of MMSE cut-off points that have been proposed for the Brazilian population, in a well defined population-based sample. A great variation in the prevalence of cognitive impairment was found when the previously recommended cut-off points were used. Agreement varied widely, reflecting the absence of consensus among Brazilian studies.

Part of the observed variation among proposed cut-off points may have been due to differences in the characteristics of the study samples. The population evaluated by Bertolucci et al. was considerably younger than other studies. Furthermore, studies were performed in diverse settings: a general hospital triage[5], a geriatric mental health outpatient clinic[7], a geriatric outpatient clinic[8] and in a community-based sample[6]. Differences in the method used to determine the recommended cut-off point(s) may also have contributed to the observed variation (for further details, see Appendix). In most cases, the cut-off that presented the best balance between sensitivity and specificity for the detection of dementia was chosen[6-8]. In one study, the 5th percentiles of MMSE scores achieved by a sample of patients at a general hospital triage were defined as the cut-off points[5].

Additionally, most of the MMSE cut-off points that have been recommended in Brazil were based on studies performed in health services[5-8], limiting their generalizability to other settings. Traditionally when validated cut-off points are not available from population-based studies, the mean and the dispersion around it (usually the mean ±2 standard deviations) are adopted as "normality" limits. However this criterion can only be used when test scores present a normal distribution. The use of the mean MMSE score ±2 SD is usually inadequate because of the absence of a normal score distribution. This was the case in the present study, where the absence of normality was evident. Furthermore, it is important to stress that it was not possible to normalize the MMSE scores of the study population, even using the types of transformation more commonly found in the literature such as logarithmic, cubic or quadratic, among others (results not shown). Thus, the use of the mean is not adequate for the MMSE score distribution in the present study[20,21].

Therefore, percentile distribution of the MMSE score seems to be the most adequate option for the study population. Scores below cut-off point 13/14 corresponded to those below the 5th percentile and the prevalence of cognitive impairment estimated using this cut-off was

4.3%. It is interesting to note that this prevalence is very similar to the one found in an area of the city of São Paulo (5.9%)[22] using the 10/66 Dementia Research Group protocol, developed to avoid educational and cultural biases in population-based studies in developing countries[23]. This prevalence is also similar to estimates for elderly in Latin America (4.6%)[24].

Regarding methodological aspects of the present study, it is important to note that the MMSE version used was adapted for populations with low schooling level. Interviews were conducted by lay-interviewers who underwent extensive training by a qualified psychiatrist. They were only certified as interviewers after intra and inter-rater reliabilities were assessed. Although the study was carried out in a population in the State of Minas Gerais with characteristics similar to the elderly Brazilian population as a whole, this does not mean it can be considered representative of the elderly population of this country. Furthermore, the study was done in a non-selected elderly population, living in the community. These measures allowed the aim of the study to be reached: to compare the estimated prevalences of cognitive impairment in a single population, using the different MMSE cut-off points proposed in the Brazilian literature.

The results of the present study show that the adoption of the cut-off points suggested in the Brazilian literature led to great variations in estimates of the prevalence of cognitive impairment in the study population. Thus, it is reasonable to consider that those cut-off points are not comparable between populations. In the absence of comparable cut-off points, percentile distribution of MMSE scores is more adequate for population-based studies of the elderly with low schooling level.

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