ARTÍCULO ORIGINAL

Mini Mental State Examination (MMSE): Cut-off Scores for Ecuadorian Adult Population

Mini Mental State Examination (MMSE): Puntuaciones de Corte Para la Población Adulta Ecuatoriana

Lila Adana-Díaz,[1] Guido Mascialino,[1] Tarquino Yacelga-Ponce,[1] César Parra-Gaete,[1] Christian Calero-Moscoso,[2] Lissette Duque-Peñailillo,[3] Mabel Torres-Tapia,[1] Alberto Rodríguez-Lorenzana[4]

Abstract

Background: The MMSE is one of the most widely used tests for the detection of dementia and cognitive impairment, however, cut-off points differ between countries.

Objective: To generate MMSE cut-off scores for the detection of Alzheimer's disease in Ecuadorian population aged 55 to 85 years.

Methods: 390 subjects were evaluated, 76 had a diagnosis of Alzheimer's disease. The level of dementia, functional autonomy, depression levels, sociodemographic and clinical variables of interest were measured. A regression model was performed to adjust the MMSE scores for the estimated values. The results were corrected using a multiple regression model. Cut-off points were obtained by ROC curve analysis.

Results: The variables Grade (T=5.2, p<0.001) and Age range (T=-7.95, p<0.001) were the only variables that had an effect on MMSE scores of 22% of the variance (R^2 *adj*Radj^2 =0.22). An education-adjusted cut-off point of 22.81 was obtained with a sensitivity of 0.97 and a specificity of 0.88.

Conclusion: This information may increase the accuracy in the use and interpretation of the MMSE in the Ecuadorian population.

Keywords: cognitive impairment, dementia, Alzheimer Disease, screening scale, educational level

Resumen

Antecedentes: El MMSE es una de las pruebas más utilizadas para la detección de demencia y deterioro cognitivo, sin embargo, los puntos de corte difieren entre países.

Objetivo: Generar puntajes de corte del MMSE para la detección de enfermedad de Alzheimer en población ecuatoriana de 55 a 85 años.

Métodos: Se evaluaron 390 sujetos, 76 tenían diagnóstico de enfermedad de Alzheimer. Se midió el nivel de demencia, autonomía funcional, niveles de depresión, variables sociodemográficas y clínicas de interés. Se realizó un modelo de regresión para ajustar las puntuaciones MMSE a los valores estimados. Los resultados se corrigieron mediante un modelo de regresión múltiple. Los puntos de corte se obtuvieron mediante un análisis de curva ROC.

Resultados: Las variables Grado (T=5,2, p<0,001) y Rango de edad (T=-7,95, p<0,001) fueron las únicas variables que tuvieron un efecto sobre las puntuaciones MMSE del 22% de la varianza (R^2 *adj*Radj^2 =0,22). Se obtuvo un punto de corte ajustado por educación de 22,81 con una sensibilidad de 0,97 y una especificidad de 0,88.

Conclusiones: Esta información puede incrementar la precisión en el uso e interpretación del MMSE en la población ecuatoriana.

Palabras clave: deterioro cognitivo, demencia, Enfermedad de Alzheimer, escala de tamizaje, nivel educativo

Rev. Ecuat. Neurol. Vol. 34, N° 2, 2025

[1]Universidad de Las Américas. Escuela de Psicología y Educación. CEC Research Group. Quito, Ecuador.
[2]Carlos Andrade Marin Social Security Hospital (HCAM). Memory and Behavioral Unit. Quito, Ecuador.
[3]Neuromedicenter. Cognitive Disorders Unit. Quito, Ecuador.
[4]Universidad Pública de Navarra. Pamplona, España

Correspondencia:
Alberto Rodríguez-Lorenzana, PhD
Universidad Pública de Navarra, Pamplona, España
E-mail: alberto.rodriguez@unavarra.es

doi: 10.46997/revecuatneurol34200029

Introduction

The Mini-Mental State Examination (MMSE) is a screening test commonly used to determine a person's level of cognitive functioning briefly and efficiently in clinical and research settings. It was developed by Folstein et al.[1] In 1975 with the aim of detecting organic problems in psychiatric patients,[2] and soon became popular and one of the most widely used tests for the detection of cognitive disorders.[3] The items of the MMSE are grouped by cognitive domains such as: orientation, registration, attention, calculation, memory, and language. The complete administration of the test takes about 5-10 minutes, which contributes to its value as a rapid assessment tool. Despite being an established and widely used test for detecting cognitive problems, the cut-off point for determining them has varied among the various studies conducted.[4] This variability, which ranges from 19 to 24 as a cut-off point depending on the study considered, is determined by the scores obtained by the population evaluated.[5,6] Consequently, the development of appropriate scales for the context in which the test will be used is essential if greater diagnostic precision is to be achieved.

The psychometric properties of the MMSE have been well established in multiple studies.[2,7] The test demonstrates good internal consistency and test-retest reliability.[1,8,9] The sensitivity and specificity of the MMSE in detecting cognitive problems varies according to the condition and sociodemographic characteristics of the sample, with the highest levels of sensitivity found in patients with dementia,[1,10] while in neurological patients, it varies significantly.[2] Tombaugh and McIntyre[2] report in their review of the MMSE literature that test specificity is good assuming a higher cut-off point and a non-clinical control group. On the other hand, performance in the MMSE has been shown to be associated with sociodemographic variables such as age, gender, and education,[2,7] which reflects the importance of taking these variables into account when generating norms.

One of the most common uses of MMSE is the detection of dementia and subsequent deterioration over time, this practice was recently supported through an extensive Cochrane review.[1] This instrument is also commonly used in hospital settings, often incorporated into initial psychiatric and neurological assessments.[11,12]

The MMSE is used globally and has been translated into more than 100 languages[13,7] and the generation of different standardized versions in the Spanish language.[14] In Ecuador, despite its common use in the identification of cognitive alterations in clinical settings, there are still no standardizations or cut-off values for the population, which implies that the test is used informally as a diagnostic tool, which may imply the presence of false positives and the difficulty in developing effective rehabilitation programs.

Currently there is normative data for in MMSE in countries such as Spain,[15,16] Chile[17] and Argentina.[14] Ecuador shares the Spanish language with these countries; however, cultural differences do not allow for the extrapolation of usage norms and standardization values.[18] Now, there is a significant lack of normative data for clinical and neuropsychological assessment tests in Latin America.[19]

Ecuador is not an exception to the global trends in cognitive assessment. Given the widespread use of the MMSE in the country, the present study aimed to develop adjustment coefficients and cut-off scores for the Ecuadorian version of the MMSE to enhance the detection of cognitive impairment secondary to Alzheimer's disease in individuals aged 55 to 85 years. The proposed adjustment coefficients are intended to be user-friendly, avoiding complex formulas that may confuse test administrators, and to facilitate more accurate score interpretation by accounting for sociodemographic influences that could impact clinical diagnoses. We hypothesize that by controlling sociodemographic variables such as age and educational level and applying an adjusted cut-off score, the diagnostic accuracy of the MMSE will be enhanced.

Methodology

Participants

The final sample was composed of 390 people belonging to the Metropolitan District of Quito, Ecuador; of these 314 people are part of the control group and 76 people had a pre-existing Alzheimer's disease diagnosis. The age of the participants varied from 55 to 85 years old (M=69.5, SD=8.49). Schooling varied from 3 to 25 years; the largest group was 12 years of studies (38.64%). Most participants were women (53.16%). The sample was mostly urban (77.93%). For the categorization of socioeconomic levels, the stratification criteria of the Instituto Nacional de Estadísticas y Censos (INEC) were used, which establishes that the country's households are divided into five strata: A, B, C+, C-, and D.[20] The most represented socio-economic group was B (35.22%) and 19% of the sample was diagnosed with dementia and 81% is a control sample.

The sampling strategy was determined considering factors such as literacy level; percentage of people with primary, secondary, and tertiary education; socio-economic group and age distribution. The comparison between the control group and the study group shows statistically significant differences in the sociodemographic variables Schooling Rank ($X2$=30.04, p<0.001), Marital Status ($X2$=30.37, p<0.001), Area of Residence ($X2$=71.33, p<0.001), Socioeconomic Status ($X2$=278.1, p<0.001) and Age Rank ($X2$=314.27, p<0.001).

An extension of these data can be found in Table 1.

Table 1. Sociodemographic characteristics of the groups (control and dementia).

Variable	Control	Dementia	X^2 (*p value*)
Sex			
Female	167(53.18%)	38 (50%)	1.27 (0.26)
Male	147 (46.82%)	38 (50%)	
Grade Level			
1 to 6	75 (23.89%)	26 (34.21%)	30.04(<0.001)
7 to 12	111 (35.35%)	29 (38.16%)	
>12	128 (40.76%)	21 (27.63%)	
Civil Status			
Married	187 (87.8%)	36 (70.59%)	30.37(<0.001)
Single/Widowed	26 (12.2%)	15 (29.41%)	
Area of Residence			
Urban	235 (72.95%)	68 (89.47%)	71.33(<0.001)
Rural	79 (27.05%)	8 (10.53%)	
Socioeconomic Status			
A	69 (22.26%)	3 (3.95%)	278.1(<0.001)
B	110 (35.48%)	29 (38.16%)	
C+	82 (26.45%)	30 (39.47%)	
C-	49 (15.81%)	14 (18.42%)	
Age Range			
55-64	120 (38.22%)	9 (11.84%)	314.27(<0.001)
65-74	119 (37.89%)	16 (21.05%)	
75-84	75 (23.89%)	51 (67,11%)	

In order to include the participants in the study, they had to meet the following requirements: a) be between 55 and 85 years old, b) be born and currently living in Ecuador, c) have Spanish as their native language, d) have completed at least one year of formal education, e) be able to read and write at the time of the evaluation, f) obtain a score below 0 on the Clinical Assessment of Dementia (CDR),[21,22] g) obtain a score below the cut-off point established according to age that indicates independence on the Inventory of Functional Abilities of Adults and Elders (IAFAI),[23] h) obtain a score below 5 on the Geriatric Depression Scale (GDS).

A sociodemographic questionnaire was applied to collect information on medical history, health status and income of the subjects. It was determined that subjects would not participate in the study if they did not report or support the following: (a) history of medical services received for diagnosed neurological or psychiatric conditions, (b) daily consumption and/or use of an illicit substance, (c) history of systemic disease affecting cognition (e.g., diabetes mellitus), (d) regular use of medications that may affect cognitive functioning, and/or (e) severe visual and/or hearing deficits and/or (f) history of learning disabilities or neurodevelopmental problems.

Instruments

The instruments used for data collection were the following:

Sociodemographic questionnaire: Designed to identify exclusion criteria and collect information on educational and economic level, age, sex, and residence (rural, urban).

Clinical assessment of dementia CDR:[21,22] It is a scale for clinical assessment of dementia that evaluates six domains: memory; orientation, problem solving, community activities, home, hobbies, and personal care whose overall score varies between zero and three. It has a Cronbach alpha reliability value of 0.86.[24]

Inventory of Functional Adult and Elderly Abilities (IAFAI):[25] Allows for the assessment of autonomy in activities of daily living; evaluates three functional domains: Basic Activities of Daily Living, Instrumental Activities of Daily Living Family and Instrumental Activities of Daily Living Advanced. It has 50 items in the form of a semi-structured interview and has an internal consistency of 0.93 and a reliability of 0.79.[23]

GDS Geriatric Depression Scale: it allows evaluating the presence of depressive symptoms. For this study, the abbreviated version was used, which has 15 questions scored with one point each, giving a total score from 0 to 30 and a Cronbach's alpha value of 0.95.[26]

Mini Mental State Examination-2: Test used to evaluate general cognitive function, has an alpha value of 0.78 in this sample.[27] It evaluates six cognitive domains: Orientation, Retention, Attention and Calculation, Evocation, Language, and Constructive Ability through 30 questions evaluated with 1 point each with a minimum of 0 and a maximum of 30.

Data analysis

The effect of sociodemographic variables on the MMSE scores of subjects without pathology was tested by multiple linear regression assuming MMSE scores as the dependent variable and age, sex, years of schooling, marital status, area of residence and socioeconomic status as independent. Each variable was evaluated separately and included in the final model if its significance was confirmed in the simultaneous regression with the other significant individual predictors.

The values estimated by the regression model were used to adjust the original MMSE scores to the significant sociodemographic variables and a direct score correction table has been developed using the multiple regression model obtained in previous steps. Finally, the regression model obtained for the sample without pathology was used to adjust the scores of the sample with Alzheimer's disease and use both adjusted scores to obtain the cut-off point with the highest possible level of sensitivity and specificity. All analyses were performed using R Studio statistical software version 4.0.2.[28]

Results

The mean MMSE score in the control group was 26.74 (1.92) while for the Alzheimer's group it was 17.86 (5.38). Statistically significant differences were therefore found in the mean score of both groups ($T=14.18$, $p<0.001$). Only the control group was used to create the regression scores and analysis, and the following results were found a positive relationship was identified between the scores and the Grade Level (p<0.001) and a negative relationship with Age Range (p<0.001). The variables sex (p=0.882), marital status (p=0.387), areas of residence (p=0.146) and socioeconomic status (p=0.399) did not present statistically significant effects. Table 2 shows the final regression model (F=43.96, *R2adj*=0.22, p<0.001). Table 3 shows the correction grid obtained from the regression analysis.

Finally, with the direct scores, a cut-off point of 24 direct points was obtained with a sensitivity of 0.93 and a specificity of 0.92, which allows 92.82% of the cases to be correctly differentiated. When using the transformed scores with the correction grid, a cut-off point of 22.81 was obtained with a sensitivity of 0.97 and a specificity of 0.88, which allows 95.13% of the cases to be correctly differentiated. View Figure 1, 2.

Discussion

The objective was to generate cut-off scores for the MMSE to differentiate between a healthy and a pathological population, namely AD, in an Ecuadorian population, and taking into consideration the effect of sociodemographic variables such as age, gender, socioeconomic level and schooling of the participants.

The variables age and schooling turned out to be the only ones that present an effect on the MMSE scores. The final regression model explained 20% of the variance with these variables. Years of schooling are positively related to performance in the MMSE, while age presents a negative relationship.

The results of this study are consistent with those of research in multiple Latin American countries that established a relationship between education level, age, and MMSE score. Infante[15] developed scales for the MMSE in the coastal region of Argentina with 1154 participants between the ages of 18 and 65, and found that, together, these explained approximately 50% of the variance in MMSE scores. Scaling of the MMSE in Chile in a study with 2978 participants and a wide age range also found a strong relationship between MMSE scores and age and education.[29] Similar results have also been found in Colombia,[30] Mexico,[31] and Brazil.[32]

In this study no relationship was found between MMSE scores and gender, which is consistent with multiple studies conducted on this test.[7] The variable of socioeconomic group was also not significant in this study, in contrast to other investigations in diverse regions of the world that have demonstrated an association between socioeconomic level and performance in the MMSE.[33,34] However, the measurement of socioeconomic level was not uniform across studies, which limits its interpretation in relation to the current study.

The cut-off point of this study[22] is similar to the obtained

Table 2. Final model of regression in cognitive performance (MMSE).

Variable	B	STD error	T	p
Age Range	1-0.03	0.01	-7.95	0.009
Grade Level	0.17	0.02	5.2	<0.001

*Final multiple regression model with significant variables, B=slope of the variable, R2adjRadj2=0.22.

Table 3. MMSE correction grid according to educational level

Grade Level / Age Range	55-64	65-74	75-84
1 to 6	0	0.39	0.77
7 to 12	-1.1	-0.71	-0.33
>12	-1.96	-1.57	-1.19

*Primary school level and the age range of 55-64 years is the base group so there is no correction in the score.

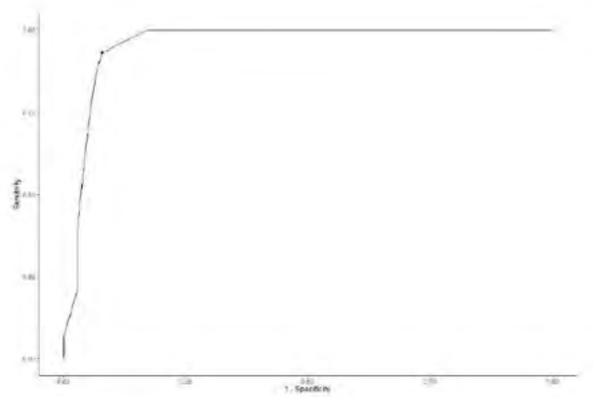

Figure 1. ROC curve for direct scores.

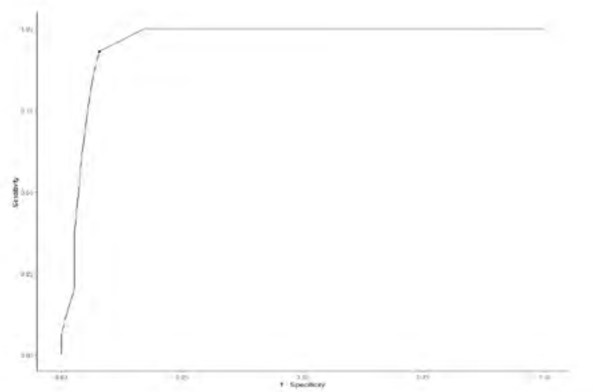

Figure 2. ROC curve for correction grid scores.

in Mexico,[35] which determines it at 23/24 points, with a sensitivity of 0.97 and a specificity of 0.88. It differs from the cut-off point obtained in Chile,[36] which was 21/22. However, the studies in these countries and Colombia[30] share that the variation of the cut-off point depends on the age, sex, and educational level of the participants. Above all, there is a significant correlation between the educational level and the cut-off point; the highest cut-off points were obtained by subjects with educational levels higher than six years.[37] Using this test in subjects with low levels of education or with mild cognitive impairment would be inappropriate.[30]

There is only one previous study of the MMSE in Ecuador. Espinosa del Pozo and collaborators,[38] administered the MMSE to 144 subjects over the age of 65 to detect dementia and cognitive impairment. The authors found that 40% of the population had cognitive deficits. The authors used a cut-off point of 23 to classify cognitive impairment. Given that 78% of the sample had 6 or fewer years of education, and considering the results of the present study, it is very likely that this cut-off point is not appropriate for the Ecuadorian population. The mean score in the MMSE varies substantially according to the level of education in this study, which emphasizes the importance of basing it on scales appropriate to the Ecuadorian context.

In this context, our findings show that using a cut-off point of 22 allows for correctly identifying 95.13% of mild cognitive impairment cases in Ecuador. This reinforces the need to adjust cut-off points to local characteristics, improving the MMSE's accuracy in both diagnosis and follow-up. Thus, the MMSE becomes a more reliable tool for use in Ecuador, helping to avoid over or under diagnosis.

Consequently, the use of appropriate scales to detect cognitive problems using screening is essential if over- or under-scoring of pathology in treated or studied populations is to be avoided. The demonstrated diagnostic precision of 95.13% with the adjusted cut-off reinforces the relevance of adapting cognitive assessment tools to local demographics and supports the implementation of this approach in clinical protocols. It is expected that the current study will contribute to improve accuracy in detecting cognitive problems, so that people who have been correctly evaluated with the MMSE can receive the necessary care.

This study has several strengths. The use of a correction grid has proven to be a quick and easy way to control for the effect of demographic variables, in this case age and education. The correction grid elaborated during this research allows to correctly diagnose 95.13% of the population compared to the 92% achieved by the direct scores. This improvement in diagnostic accuracy further supports the clinical applicability of the proposed cut-off in Ecuadorian healthcare settings. Therefore, its use would prove useful for health care workers using this test in diagnosis. Another strength of this study is the rigor utilized in identifying a clinical sample, which included results from blood work, neuroimaging, and meeting stringent dementia criteria as determined by a neurologist. Lastly, multiple sociodemographic variables were considered, including place of residence (rural vs urban) and socioeconomic status.

Limitations

It is necessary to mention that, although the sample size is adequate for the objective of the study, the population evaluated was limited to the regions of the mountain range of the country, which represent 44.52% of the total census, for this reason the results should be generalized with caution in other areas. Future studies should expand the sample to achieve a greater representation of the different territories of the country. On the other hand, the place of residence of a significant part of the participants was urban, 72.9% versus 27.1% of the rural population. This makes it difficult to generalize, considering that Ecuador is a country with a high percentage of rural population (37.24%). Finally, there could be a bias stemming from the way the sample is accessed.

Conclusions

This is the first study in the country to generate cut-off scores for one of the most widely used instruments in clinical settings for identification of dementia and cognitive impairment. Having population-adjusted data will allow professionals to make more accurate inferences from the scores and avoid the current need to use raw or normative data from other countries in the interpretation of the MMSE. Presumably, this would improve diagnostic systems, as it will contribute to the early detection of Alzheimer's, other dementias and better establish their prognosis and rehabilitation programs in the Ecuadorian population.

Although sex is not a variable that directly influences the results, it is confirmed that the educational level and age are related to the performance in this test, and it is considered that the inclusion of sociodemographic correction scores in the calculation of cut-off values in this study solves one of the limitations raised in previous similar studies and improves the accuracy of the data.

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Conflict of Interests Statement: *The authors have no conflicts of interest to declare.*
Ethics statement: *All participants provided informed consent prior to participating in the study. This study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Bioethics Committee of the Universidad San Francisco de Quito under approval number 2017-2019 in 2017.*
Data availability: *The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy concerns, as they contain information that could compromise the confidentiality of research participants.*
Funding: *The development of the project from which the writing of this article has derived has been completely financed by Universidad de Las Américas (Ecuador) and carried out in the installations of this Institution.*