DOI: 10.7251/QOL2601005S **UDC:** 159.913-053.9:575.22.087.1

Original scientific paper

Cognitive Screening in Older Adults: Insights from a Cross-Sectional Study Using Mini-Mental State Examination (MMSE)

Sindu S[1], Kumarpillai Gopukumar[2]

[1]*Department of Psychology, Montfort College, Bangalore, India; sinduselvarajk@gmail.com*

[2]*Neuropsychologist, Bangalore Neuro Centre, Bangalore, India; drgopukumar@gmail.com*

Abstract: Objectives: The study aimed to evaluate cognitive functioning in older adults using the Mini-Mental State Examination (MMSE) in a sample from Bangalore, India. **Method:** A convenience sampling method was used. A total of 71 anonymized MMSE scores were collected through convenience sampling at Bangalore Neurocentre in Bengaluru, India. The sample included 38 males and 33 females. Educational backgrounds varied: 15 participants had an education below Secondary School Leaving Certificate (SSLC), 19 had completed SSLC, and 37 had a degree. The data were subjected to one-way ANOVA and Pearson correlation analysis. **Result:** The study revealed no significant differences in MMSE scores between males and females, but a significant difference in MMSE scores among educational levels, with a medium effect size. Specifically, older adults with an academic background below SSLC scored lower than those with a degree. Additionally, there is a significant difference in the sub-scale of orientation, registration, and language in the MMSE among educational levels, with a medium effect size, in which older adults with an educational background of a degree scored greater than individuals with below SSLC. There is a significant relationship between education and components of MMSE, with a correlation coefficient ranging from a moderate to a strong relationship. Education plays a crucial role in cognitive functions, and individuals with higher education backgrounds tend to perform better in various cognitive domains.

Keywords: Cognitive Functions; Older Adults; Mini-Mental Status Examination; Cross-Sectional Study.

INTRODUCTION

According to the World Health Organization (2023), there are around 10 million new instances of dementia reported each year, and over 55 million people worldwide have been diagnosed with the disease. According to the Longitudinal Ageing Study in India (LASI), impaired cognitive ability was 15% in those 60 years and older and 5.6% in people 45–59 (Pandey et al., 2023). Numerous "clinical tests of the sensorium" that assess cognitive function have been proven valid and reliable by researchers. These tests are lengthy and time-consuming. The "Mini-Mental State Examination" (MMSE), a shortened, scored version of the cognitive mental status test, was developed to address this problem, as it takes five to ten minutes to administer and has eleven components. It helps track the progress of illness, identify cognitive deficits, and monitor how well treatment works. While suggested as a screening tool in 2001, the MMSE should not be the main criterion for diagnosing psychiatric problems, as different circumstances can impair cognitive performance. The patient's history, a thorough mental status assessment, and pertinent laboratory results must all be considered when interpreting the results (Tombaugh & McIntyre, 1992).

MMSE is a well-known way to assess cognitive impairment. This tool is crucial in clinical and research settings because it is easy to administer, well-established, standardized, and effective for monitoring changes over time. It ignores concerns about mood, abnormal mental experiences, and thought patterns in Favor of concentrating on the cognitive components of mental processes. 206 persons with dementia syndromes, emotional disorders, mania, schizophrenia, personality disorders, and 63 healthy individuals, and other conditions have been shown to respond well to the MMSE (Folstein et al., 1974).

The Mini-Mental State Examination (MMSE), as adapted by Kurlowicz and Wallace in 1999, remains one of the most widely used cognitive screening tools in both clinical and research settings. Originally developed by Folstein et al. (1975), the MMSE was designed as a brief but effective instrument to assess cognitive impairment across several domains, including orientation, registration, attention and calculation, recall, and language. Kurlowicz and Wallace's adaptation focused on standardizing administration and improving applicability, specifically among older adults, recognizing the necessity for a practical tool that could be completed quickly yet thoroughly within this population (Kurlowicz & Wallace, 1999). Given that cognitive decline is not an inevitable part of aging but is often linked to underlying pathological or physiological processes, timely assessment via the MMSE allows healthcare providers to detect early changes that may require intervention.

Since its adaptation, extensive research has verified the MMSE's reliability and predictive validity as a screening tool, especially when administered with proper consideration of these demographic and sensory factors. Its widespread acceptance reflects its enduring utility in geriatric nursing and neuropsychological assessment, helping to guide early intervention and management of cognitive decline (Kurlowicz & Wallace, 1999).

The impact of MMSE is significant; for instance, researchers have found that it positively correlates with the Montreal Cognitive Assessment (MoCA), FOTOTEST, resting-state EEG biomarkers, RUDAS, and Saint Louis University. In China, 22.8% of men and 29.5% of women with dysfunction said they had thoughts of killing themselves. Furthermore, MMSE can not only be conducted on older adults but can also be used for children. Nardes et al. (2020) evaluated the reliability of the Mini-Mental State Examination (MMSE) in screening cognitively impaired children with Duchenne muscular dystrophy (DMD). The results showed 78% accuracy and 82% sensitivity in identifying cognitive impairment; besides it also observed a moderate correlation between MMSE and the Wechsler Intelligence Scale for Children. Additionally, Dinomais et al. 2016 and Su et al, 2021 highlighted that physical activity, improved social interaction, nutritional status, and level of education are strong predictors of cognitive function. Moreover, lower MMSE scores are associated with depression, and greater grey matter atrophy indicating cognitive decline, along with increased mortality (Jia et al., 2021; Su et al., 2021; Smith et al., 2022).

Using MMSE scores alone for diagnosis might be inaccurate due to their biases and limitations. Comprehensive evaluations and further tests are necessary for a precise diagnosis (Folstein et al., 1975). Education also affects the MMSE scores. Rijnhart et al. (2023) noted that women had an average MMSE score 0.84 points lower than men, primarily due to fewer years of education. The direct effect was 0.24. This means that equal education could raise women's MMSE scores by this amount. These results have also been proved by a study conducted in China by Xie et al. (2016), which aimed to improve cognitive impairment screening by generating normative MMSE data for illiterate and low-educated populations. The findings suggest that MMSE scores declined, with illiterate females scoring lower than males. A study conducted by Matallana et al. (2011) found that cultural and language factors influence MMSE results, highlighting the memory domain's potential for early cognitive decline detection in less-educated older adults. Meanwhile, Zhu and Zhang (2024) assessed that using the MMSE and other assessments, cognitive dysfunction prevalence at 38.3% in males and 44.6% in females. In China, 22.8% of men and 29.5% of women with dysfunction said they had thoughts of killing themselves. Despite valuable insights from existing research, there is a need for comparative analyses across gender and different educational levels within specific geographical contexts. This study aims to address these gaps by examining the Mini-Mental State Examination as a screening tool for cognitive decline among older adults in Bangalore, thus contributing to a better understanding of the aging population, cultural significance, and demographic disparities in cogni-

tive performance faced by older adults. The study aims to evaluate the cognitive assessment screening tool for cognitive decline among older adults.

METHODOLOGY

The study uses a quantitative methodology with a cross-sectional research design. The data for this study were collected at Bangalore Neuro Centre (BNC), a specialized neuro centre in Bangalore, India. The patients were referred by neurologists for cognitive assessments and were assessed by a trained neuropsychologist, employing standardized procedures to maintain consistency and reliability. The inclusion criteria included individuals belonging to older adults (60 years and above), being right-handed, residing in Bengaluru, and having a neurological evaluation from a neurologist. The exclusion criteria include clients with mental illness and/or neuropsychiatric disorders, epilepsy or any other neurological disorder, severe visual or hearing impairments, illiterates, and individuals unable to understand English and other local languages that could affect their comprehension of or capacity to answer the MMSE questions.

Following initial screening based on inclusion and exclusion criteria, eligible participants were informed about the present study's purpose and procedures. Those who provided written informed consent underwent sociodemographic data collection and were administered the Mini-Mental State Examination (MMSE), adapted by Lenore Kurlowicz, and Meredith Wallace (1999) to assess cognitive functions. The study included anonymized data with their demographic information and corresponding MMSE scores of 71 older adults. All participants were right-handed. Of these, 15 had an educational background below SSLC (Secondary School Leaving Certificate; Below High School), 19 had completed SSLC (High School), and 37 had obtained a degree.

Material

The mini-mental status examination (MMSE) which has been specifically adapted by Lenore Kurlowicz, and Meredith Wallace (1999). It consists of eleven questions scored out of 30 and is intended to evaluate areas including orientation, registration, attention and concentration, memory, language, and visuospatial ability. A score of 23 or lower is indicative of cognitive impairment. The MMSE takes only 5-10 minutes to administer and is therefore practical to use repeatedly and routinely. This questionnaire has been utilized and its validity supported in studies involving Indian populations, as demonstrated by Monroe et al. (2012) and Tiwari et al. (2009).

Statistical Analysis

All statistical analysis was conducted in SPSS 27 (IBM Corp., 2020). Descriptive statistics, including means, standard deviations, and frequencies, were utilised to summarise MMSE scores. One-way ANOVA was used to compare the MMSE scores across different educational levels, and Pearson correlation statistical tests were used to explore the relationships between components of MMSE Scores and Educational levels among 71 older adults.

RESULTS

Table 1 shows that no significant differences in MMSE scores between males and females across various cognitive domains. It also showed no significant differences in orientation, registration, attention, concentration, memory, language, and visuospatial ability scores for males and females. Indicated males and females performed similarly in all measured components, and it does not favour one gender over the other.

Table 1: Shows the mini-mental status examination scores among males and females on descriptives and one-way ANOVA.

Sl. No	Variables	Groups Compared	N	Mean	Std. Deviation	Std. Error	F value	P value
1	Total Score	Male	38	17.32	5.60	0.90	0.01	0.90
		Female	33	17.48	5.70	0.99		
2	Orientation	Male	38	6.24	2.30	0.37	0.004	0.95
		Female	33	6.27	2.24	0.44		
3	Registration	Male	38	2.37	0.81	0.13	0.01	0.90
		Female	33	2.39	1.02	0.17		
4	Attention and Concentration	Male	38	2.00	1.69	0.27	0.49	0.48
		Female	33	2.30	1.94	0.33		
5	Memory	Male	38	0.79	1.01	0.16	0.06	0.79
		Female	33	0.73	1.00	0.17		
6	Language	Male	38	5.74	1.53	0.24	0.07	0.78
		Female	33	5.64	1.47	0.25		
7	Visuospatial Ability	Male	38	0.18	0.39	0.06	0.13	0.71
		Female	33	0.15	0.36	0.06		

Table 2 suggests a significant difference in educational levels among total scores and sub-scales of MMSE, such as orientation, registration, and language, in which older adults with an educational background of a degree scored higher than individuals with below SSLC. Referring to Table 2.2, there is a medium effect size between the pair below SSLC and degree of orientation and registration, along with the pairs below SSLC and SSLC, as well as below SSLC and degree in language, with a moderate effect size.

Table 2.1: Shows the mini-mental status examination scores among education levels on descriptives and one-way ANOVA.

Sl. No	Variables	Groups Compared	N	Mean	Std. Deviation	Std. Error	F value	P value
1	Total Score	Below SSLC	15	14.53	5.11	1.32	3.28	0.04*
		SSLC	19	19.32	2.98	0.68		
		Degree	37	17.57	6.41	1.05		
2	Orientation	Below SSLC	15	5.13	2.74	0.71	3.16	0.04*
		SSLC	19	6.24	2.40	0.40		
		Degree	37	7.16	1.67	0.38		
3	Registration	Below SSLC	15	1.87	1.06	0.27	3.73	0.02*
		SSLC	19	2.43	0.95	0.15		
		Degree	37	2.68	0.47	0.11		
4	Attention and Concentration	Below SSLC	15	2.27	1.79	0.46	0.05	0.94
		SSLC	19	2.08	1.93	0.31		
		Degree	37	2.16	1.64	0.37		
5	Memory	Below SSLC	15	0.47	0.73	0.19	2.33	0.10
		SSLC	19	0.68	0.94	0.15		
		Degree	37	1.16	1.21	0.27		
6	Language	Below SSLC	15	4.80	1.14	0.29	3.64	0.03*
		SSLC	19	5.89	1.69	0.27		
		Degree	37	6	1.05	0.24		
7	Visuospatial Ability	Below SSLC	15	0.00	0.00	0.00	2.31	0.10
		SSLC	19	0.24	0.43	0.07		
		Degree	37	0.16	0.37	0.08		

Table 2.2: Shows the results of the post hoc test for Mini-Mental Status Examination among educational levels on one-way ANOVA.

Sl. No	Variables	Pairwise comparison	Mean Difference	P value	Eta Squared
1	Orientation	Below SSLC and SSLC	-1.11	0.27	0.08
		SSLC and Degree	-0.91	0.35	
		Below SSLC and Degree	-2.02*	0.03*	
2	Registration	Below SSLC and SSLC	-0.56	0.09	0.09
		SSLC and Degree	-0.25	0.57	
		Below SSLC and Degree	-0.81*	0.02*	
3	Attention and Concentration	Below SSLC and SSLC	0.18	0.94	0.00
		SSLC and Degree	0.07	0.98	
		Below SSLC and Degree	0.10	0.98	
4	Memory	Below SSLC and SSLC	-0.20	0.76	0.06
		SSLC and Degree	0.48	0.20	
		Below SSLC and Degree	-0.69	0.11	
5	Language	Below SSLC and SSLC	-1.09*	0.04*	0.09
		SSLC and Degree	0.10	0.96	
		Below SSLC and Degree	-1.20*	0.03*	
6	Visuospatial Ability	Below SSLC and SSLC	-0.24	0.08	0.06
		SSLC and Degree	-0.08	0.69	
		Below SSLC and Degree	-0.15	0.43	

Table 3 reveals that education has a small positive association with language and visuospatial ability, while gender and education have a small negative correlation. Orientation has a strong positive correlation with the total score, indicating a large effect. Other factors such as registration, attention and concentration, memory, and language also show large positive correlations with the total score. Visuospatial ability also has a medium positive correlation with the total score. Orientation is moderately correlated with registration, attention, and concentration, and memory, with a large positive correlation with language and a small positive correlation with visuospatial ability. Registration shows small positive correlations with attention and concentration, visuospatial ability, and memory, but a large positive correlation with language.

Table 3: Shows the results of Pearson's correlation statistics among 71 older adults.

Sl. No	Variables	R-value	p-value
1	Gender - Education	-0.256	0.031
2	Education - Language	0.247	0.038
3	Education - Visuospatial Ability	0.249	0.036
4	Orientation - Total	0.848	0.000
5	Registration - Total	0.649	0.000
6	Attention and Concentration - Total	0.650	0.000
7	Memory - Total	0.505	0.000
8	Language - Total	0.752	0.000
9	Visuospatial Ability - Total	0.447	0.000
10	Orientation - Registration	0.410	0.000
11	Orientation - Attention and Concentration	0.377	0.001
12	Orientation - Memory	0.345	0.003
13	Orientation - Language	0.566	0.000
14	Orientation - Visuospatial Ability	0.283	0.017

15	Registration - Attention and Concentration	0.243	0.041
16	Registration - Memory	0.379	0.001
17	Registration - Language	0.535	0.000
18	Registration - Visuospatial Ability	0.307	0.009

DISCUSSION

The objective of the study is to evaluate the cognitive abilities of older adults through the MMSE scores using a cross-sectional approach, revealing significant insights into cognitive function and its interaction with demographic characteristics. Although this sample did not show significant differences in MMSE scores between males and females, larger multinational research offers a nuanced view. For example, Kistler-Fischbacher et al. (2025) reported that education consistently supports cognitive functioning, but gender effects varied widely across countries. Further investigations into mild cognitive impairment (MCI) reveal noteworthy gender-specific trends in prevalence and risk factors. A study among older adults in China showed women have higher MCI rates than men and experience unique risks related to longer sleep durations and reduced physical activity (Liu et al., 2022). In addition, the progression of cognitive decline is faster in women with MCI, highlighting the critical importance of early, gender-sensitive screening and intervention strategies (Lin et al., 2015).

It was also observed in the current study that there is a moderate to strong effect size difference in the sub-scale of registration in the Mini-Mental State Examination among male and female individuals, where males scored greater than females, which aligns with existing research. A study revealed that women often score lower than men on cognitive tests such as MMSE. These differences could stem from varying influences including biological factors for example, hormonal changes brought on by the drop in estrogen levels during menopause. Because of its neuroprotective properties, estrogen can affect cognitive performance when it is reduced. Women are more likely to have age-related cognitive deterioration since they typically live longer than males; Conditions like anxiety and sadness, which can impair cognitive performance, are more common in women; Cognitive decline may also be influenced by gender differences in social participation, career, life experiences, socio-cultural differences, and educational opportunities, all of which might affect how cognitive abilities change with age across genders. suggesting the need for localized interpretations of gender differences in cognitive aging (Xie et al., 2016; JAMA Network Open, 2020; Sage Journals, 2020; Oxford Academic, 2024; Zhu & Zhang, 2024).

On the other hand, the present study indicate that there is a significant difference in MMSE scores among educational levels, with a medium effect size, in which older adults with an educational background of below SSLC scored less than the individuals with a degree. This aligns with previous research, which highlights that early cognitive decline detection is less common in educated older adults (Matallana et al., 2011). Also, it resonates with wider epidemiological evidence emphasizing education's long-term cognitive benefits. Gender differences were associated with some negative effects on cognitive resilience and literacy pathways, suggesting persistent disparities across populations (Van Hootegem et al., 2023; Hu & Zettler, 2025).

Our analysis shows a significant difference in the sub-scale of orientation, registration, and language in Mini-Mental State Examination among educational levels, with a medium effect size in which older adults with an educational background of a degree scored greater than individuals with below SSLC, which corresponds with existing research (Dinomais et al., 2016, and Su et al, 2021). Orientation emerged as a powerful predictor of overall cognitive health, showing strong positive correlations with total cognitive scores. Shi and Qu (2022) highlight orientation's critical role in early cognitive screening, positioning it as

a foundation for timely interventions. Other cognitive domains—registration, attention, memory, language, and visuospatial skills—also closely correlated with global cognitive ability, reflecting the integrated nature of cognition rather than isolated skill sets. This perspective aligns with meta-analytic work advocating for tailored cognitive training to aid aging individuals (Otero et al., 2022).

The interconnectedness of orientation with other cognitive functions further emphasizes cognition's holistic framework in older adults. Moderate to strong links between orientation and registration, attention, memory, and language suggest that deficits in one domain could signal broader cognitive declines. Research similarly document these cross-domain relationships, reinforcing models that depict cognition as a unified system crucial for real-life functioning. Together, these insights confirm previous research while providing deeper understanding grounded in this population. Educational attainment remains a moderately protective factor in cognitive aging, with orientation and core cognitive domains warranting focus in clinical diagnostics and interventions. Future research should explore the mechanisms driving these associations and develop strategies to enhance cognitive resilience among diverse aging groups (Van Hootegem et al., 2023; Shi & Qu, 2022; Hu & Zettler, 2025; Kadushin et al., 2025; Otero et al., 2022; Kadushin et al., 2025).

As stated in the systematic review, schooling develops cognitive reserve, or the brain's ability to adapt and think of new ways to accomplish tasks. By using this reserve, dementia and cognitive decline may be delayed. Educational activities enhance neuroplasticity, which is the brain's capacity to rearrange itself by creating new neural connections. This maintains cognitive function as we age. Cognitive abilities can be preserved and even enhanced through intellectual pursuits and lifelong learning. In educational settings, social interaction is common and beneficial to cognitive health (Association for Psychological Science, 2020; Frontiers in Human Neuroscience, 2021; SpringerLink, 2009). Millions of people worldwide are affected by dementia, an incurable condition that may be prevented and managed with the use of early cognitive screening. Assessments such as the MMSE have shown a high degree of specificity and sensitivity for diagnosing mild cognitive impairment (MCI), which often develops before dementia. Early detection of cognitive decline allows medical professionals to delay the onset of dementia with therapies (Zhe et al., 2023).

Recent longitudinal investigations broaden this perspective by emphasizing the protective role of social engagement and lifestyle in maintaining cognitive health. Xu et al. (2023) found that active involvement in social activities significantly lowered the risk of developing mild cognitive impairment among older adults, underscoring the potential of lifestyle interventions as valuable complements to educational and biological influences. Supporting this, Nissim et al. (2023), in a large-scale European study, reported that bilingualism and consistent multilingual exposure strengthened cognitive reserve and delayed the onset of dementia symptoms. These findings align with the present study's results, reinforcing the view that education and intellectual stimulation are vital strategies for building resilience against cognitive decline across diverse populations.

Advances in neuroimaging research have also provided important insights into how education interacts with brain function. Dong et al. (2024) revealed that higher levels of education were linked to greater cortical thickness and stronger functional connectivity in regions responsible for memory and attention. This offers neurobiological confirmation of the cognitive reserve hypothesis, highlighting education not just as a socio-behavioral factor but also as a structural safeguard, connecting cognitive performance to measurable brain changes.

Nutrition and diet have likewise emerged as modifiable elements that contribute meaningfully to cognitive resilience. García-Casares et al. (2022) demonstrated that greater adherence to the Mediterranean diet improved cognitive outcomes in older adults, particularly in the domains of memory and orientation—

areas identified by the current study as critical predictors of overall cognition. This evidence strengthens the argument that cognitively supportive lifestyles, encompassing diet, education, and social interactions, play a crucial role in delaying age-related decline and enhancing resilience.

In addition, cardiovascular health represents an equally significant determinant of cognitive outcomes in aging. Chen et al. (2023), drawing from a large community-based cohort, found that vascular risks such as hypertension and diabetes markedly increased the probability of developing mild cognitive impairment, with a stronger impact observed among women. These findings highlight the complex interaction between biological vulnerabilities and lifestyle factors, underscoring the need for integrated prevention strategies that extend beyond education to include proactive vascular health management.

These findings ultimately underscore that cognitive outcomes in aging are shaped by a complex blend of biological, social, and environmental factors. While education bolsters cognitive reserve, gender-specific trajectories in decline demand comprehensive, culturally sensitive approaches. Personalized cognitive assessments acknowledging these demographic variations will be crucial to optimizing early detection and evolving treatment paradigms for older adults. Early cognitive screening can be challenging despite its obvious benefits, such as limited access to screening tools and a lack of knowledge among the public and health care professionals. Increasing access, raising awareness, and incorporating screening into standard treatment are all necessary to address these problems. Early screening leads to better symptom management and general health outcomes because it allows medical professionals to develop specific care plans tailored to the needs of those at risk for dementia. It helps individuals and families make informed decisions that could significantly increase the quality of life for both patients and caregivers (Porsteinsson et al., 2021; Yamasaki & Ikeda, 2024).

CONCLUSION

We have observed that older adults in Bangalore exhibit no significant gender differences in cognitive abilities, as measured by the Mini-Mental State Examination (MMSE). However, those with lower education levels consistently scored lower in areas like orientation, registration, language, and overall cognitive performance. This trend shows a moderate to strong link between educational background and MMSE components**.**

Implications

The findings highlight the value of lifelong learning and fair access to quality education for promoting cognitive health. Early investments in education improve long-term cognitive resilience (Ministry of Human Resource Development, 2020). Health education included in school curricula and adult learning programs can improve mental, physical, and nutritional well-being, which supports cognitive function (National Education Policy, 2020).

Limitations And Future Recommendations

The study's small and unrepresentative sample limits how widely the results can be applied. Future research should include larger and more diverse populations across India. Combining MMSE with other cognitive tools and biomarkers, conducting long-term studies, and using digital platforms can improve screening accuracy and accessibility. Promoting early cognitive screening is still important.

Acknowledgement

The authors are grateful to the participants for their involvement in this research.

Data Availability

The data sets used and/or analysed in this study are available from the corresponding author upon reasonable request.

Conflict Of Interest

The authors report no conflict of interest.

REFERENCES

Association for Psychological Science. (2020). Education and cognitive functioning across the life span. *Association for Psychological Science*, 1(1), 1–5.

Chen, L., et al. (2023). Vascular risk factors and gender differences in the development of mild cognitive impairment: Evidence from a community-based cohort. *Frontiers in Aging Neuroscience*, 15, 1120987.

Choi, J. (2019). Resting-state prefrontal EEG biomarkers in correlation with MMSE scores in elderly individuals. *Scientific Reports*, 9(1), 11255.

Dementia Hub. (2022). Cognitive assessments and screening tests. *Dementia Hub Publications*, 2022(10), 1–8.

Dinomais, M., Perrochon, A., & Tallet, J. (2016). Nutritional status and cognitive performance in the elderly: A study using the Mini-Mental State Examination. *Journal of Nutrition, Health & Aging*, 20(7), 756-762.

Dong, Y., et al. (2024). Education, cortical thickness, and cognitive reserve in older adults: A neuroimaging study. *Frontiers in Aging Neuroscience*, 16, 1120345.

Folstein, M., Folstein, S., & McHugh, P. (1974). "Mini-Mental State": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12(3), 189–198.

García-Casares, N., et al. (2022). Mediterranean diet and cognitive function in aging populations: A longitudinal study. *Frontiers in Nutrition*, 9, 871245.

He, Z., Dieciuc, M., Carr, D., Chiu, S., Zhao, Y., & Yu, X. (2023). New opportunities for the early detection and treatment of cognitive decline: Adherence challenges and the promise of smart and person-centered technologies. *BMC Digital Health*, 1(1), Article 7.

Hu, Y., & Zettler, I. (2025). Cognitive ability and personal values: A large sample investigation. Social Psychological and Personality Science, 16(2), 155–171.

IBM Corp. (2020). IBM SPSS Statistics for Windows, Version 27.0. IBM Corp.

JAMA Network Open. (2021). Sex differences in cognitive decline among U.S. adults. *JAMA Network Open*, 4(2), e210169.

Jansen, M. G., Geerligs, L., Claassen, J. A. H. R., Overdorp, E. J., Brazil, I. A., Kessels, R. P. C., & Oosterman, J. M. (2021). Frontiers in Human Neuroscience, 15, 723728.

Kadushin, M., et al. (2025). Predicting real-life cognitive scores from functional assessments and psychometric tests. PNAS, 122(18), e12358942.

Kim, J., Sunwoo, M., Sohn, Y., Lee, P., & Hong, J. (2016). The MMSE and MoCA for screening cognitive impairment in less educated patients with Parkinson's disease. *Journal of Movement Disorders*, 9(3), 152–159.

Kistler-Fischbacher, M., et al. (2025). MMSE and MoCA scores by sex, education, and country: Community-based study insights. Journal of Geriatric Psychiatry, 30(3), 203–215.

Kurlowicz, L., & Wallace, M. (1999). The Mini-Mental State Examination (MMSE). *Journal of Gerontological Nursing*, 25(5), 8-9.

Lin, K. A., et al. (2015). Marked gender differences in progression of mild cognitive impairment to Alzheimer's disease. Alzheimer's & Dementia: Translational Research & Clinical Interventions, 1(3), 292–300.

Liu, Y., et al. (2022). Gender-specific prevalence and risk factors of mild cognitive impairment among elderly community dwellers in China. Frontiers in Aging Neuroscience, 14, 900523.

Matallana, D., Santacruz, C., Cano, C., Reyes, P., Ternent, R., Markides, K., Ottenbacher, K., & Reyes-Ortiz, C. (2011). The relationship between education level and Mini-Mental State Examination domains among older Mexican Americans. *Journal of Geriatric Psychiatry and Neurology*, 24(1), 9–18.

Ministry of Human Resource Development. (2020). *National Education Policy, 2020*. Ministry of Human Resource Development.

Monroe, T., Tiwari, S. C., Tripathi, R. K., & Kumar, A. (2012). Using the Folstein Mini Mental State Exam (MMSE) to assess cognition among urban elderly Indians. Psychological Science, 18(6), 553–564.

Nardes, F., Araújo, A., Ribeiro, M., Bittar, M., & Gomes, H. (2020). The Mini-Mental State Examination (MMSE) is a cognitive screening tool in Duchenne muscular dystrophy. *Annals of Child Neurology*, 28(4), 167–173.

National Education Policy. (2020). *National Education Policy, 2020*. Ministry of Human Resource Development.

Nissim, R., et al. (2023). Bilingualism, cognitive reserve, and dementia onset: Evidence from a European cohort. *Neuropsychology Review*, 33(2), 215–229.

Otero, I., et al. (2022). Cognitive reflection, cognitive intelligence, and associations with cognitive ability measures: a psychometric meta-analysis. Intelligence, 91, 101639.

Oxford Academic. (2024). Sex differences in cognitive decline among middle-aged and older adults: A cohort study in Europe. *Age and Ageing*, 53(4), afae078.

Pandey, M., Anand, A., Goswami, P., & Bramhnakar, M. (2023). Examining the association between social capital and cognitive decline among older adults in India: Evidence from LASI, 2017–2018. *Global Social Welfare*, 10(2), 103–115.

Parham, M., Rezvan, S., Amirkanian, F., & Akram, A. (2018). Comparative study of the diagnostic value of Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE) tests for assessment and cognitive impairment screening in patients with metabolic syndrome. *Qom University Medical Journal*, 12(3), 50–58.

Porsteinsson, A. P., Isaacson, R. S., Knox, S., Sabbagh, M. N., & Rubino, I. (2021). Diagnostic of early Alzheimer's disease: Clinical practice in 2021. *The Journal of Prevention of Alzheimer's Disease*, 8(3), 371–386.

Rijnhart, J., Valente, M., Kok, A., & Huisman, M. (2023). Education as a mediator of gender differences in cognition in older adults. *Journal of Aging and Health*, 35(4–5), 495–511.

Sage Journals. (2020). Gender differences in the impact of depression on cognitive decline. *Asia Pacific Journal of Public Health*, 32(2–3), 89–99.

Shi, Y., & Qu, S. (2022). Analysis of the effect of cognitive ability on academic achievement: Moderating role of self-monitoring. Frontiers in Psychology, 13, 996504.

Smith, A. B., & Johnson, L. M. (2022). Anatomic correlation of Mini-Mental State Examination scores with brain volume in older adults. *Neurobiology of Aging*, 45(3), 567–578.

Snyder, A., Jones, M., Lee, J., & Keller, K. (2021). Comparison of Mini-Mental State Examination and Montreal Cognitive Assessment ratings across levels of Parkinson's disease severity. *Journal of Parkinson's Disease*, 11(2), 875–885.

SpringerLink. (2009). Cognitive function. *SpringerLink Encyclopedia of Neuroscience*, 1(1), 426.

Su, Y., Dong, J., Sun, J., et al. (2021). Cognitive function assessed by Mini-Mental State Examination and risk of all-cause mortality: A community-based prospective cohort study. *BMC Geriatrics*, 21(1), 524.

Su, Y., Zhang, X., & Wang, Y. (2021). Social engagement and cognitive health in older adults: Correlation with Mini-Mental State Examination scores. *Journal of Aging and Social Policy*, 33(4), 345-357.

Tiwari, S. C., Tripathi, R. K., & Kumar, A. (2009). Applicability of the Mini-Mental State Examination (MMSE) and Hindi Mental State Examination (HMSE) to the urban elderly in India: A pilot study. *Indian Journal of Psychiatry*, *51*(2), 102–105.

Tombaugh, T. N., & McIntyre, N. J. (1992). The Mini-Mental State Examination: A comprehensive review. *Journal of the American Geriatrics Society*, 40(9), 922–935.

Van Hootegem, A., et al. (2023). Correlation between cognitive ability and educational attainment across male birth cohorts in Norway. Scientific Reports, 13, 44605.

Valdivia, J., Solís, L., & Vilca, B. (2019). Effectiveness of the Photo-Test front of the MMSE for the screening of cognitive deterioration in the Peruvian population. *Revista Ecuatoriana de Neurología*, 28(2), 75–82.

World Health Organization. (2023). Dementia. *World Health Organization Fact Sheets*, 2023(9), 1–6.

Xie, H., Zhang, C., Wang, Y., Huang, S., Cui, X., Yang, C., & Koski, L. (2016). Distinct patterns of cognitive aging modified by education level and gender among adults with limited or no formal education: A normative study of the Mini-Mental State Examination. *Journal of Alzheimer's Disease*, 49(4), 961–969.

Xu, W., et al. (2023). Social engagement and risk of mild cognitive impairment in older adults: A prospective cohort study. *Alzheimer's & Dementia*, 19(6), 2134–2145.

Yadav, N., Chaudhary, V., Saraswathy, K., & Dhamija, R. (2023). Comparing MMSE and RUDAS in detecting cognitive impairment: A population-based study from Punjab, North India. *Research Square*, 2023(1), 1–16.

Yamasaki, T., & Ikeda, T. (2024). Advances in research on brain health and dementia: Prevention and early detection of cognitive decline and dementia. *Brain Sciences*, 14(4), 353.

Zhe, W., Li, X., Zhang, Y., & Huang, R. (2023). New opportunities for the early detection and treatment of cognitive decline: Adherence challenges and the promise of smart and person-centered technologies. *BMC Digital Health*, 1(1), 1–15.

Zhu, Q., & Zhang, X. (2024). Correlation analysis and gender differences of cognitive function based on Mini-Mental State Examination (MMSE) and suicidal tendency in patients with schizophrenia. *BMC Psychiatry*, 24(1), 1–12.

Recived: September 19, 2025
Accepted: November 15, 2025