Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Comparative Performance of Conventional, Informant-Based, and Digital Cognitive Screening Tools in Community-Dwelling Older Adults: A Cross-Sectional Study

Hui-Chu Chuang
Tungs' Taichung MetroHarbor Hospital
Ming-Han Hsieh
Tungs' Taichung MetroHarbor Hospital
Ching-Yang Huang
Taipei Medical University
Yu-Che Cheng
Tungs' Taichung MetroHarbor Hospital
Shang-Chien Huang
huangsc190@yahoo.com.tw
Tungs' Taichung MetroHarbor Hospital

Research Article

Keywords: dementia, cognitive impairment, cognitive screening, MoCA, MMSE, AD8, CogMate, digital cognitive assessment, Clinical Dementia Rating

Posted Date: September 21st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10608928/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Early identification of cognitive impairment is increasingly important in aging societies. Multiple cognitive screening tools are available, but their diagnostic strengths and clinical roles may differ according to healthcare setting and screening purpose. This study aimed to provide quantitative evidence for selecting and combining conventional, informant-based, and digital cognitive assessment tools in different clinical scenarios.

Methods

This cross-sectional community-based cognitive screening study included 250 community-dwelling older adults aged 65 years or older who were recruited between March 2025 and June 2025. Participants underwent cognitive assessment using the Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), reverse-scored AD8, Clinical Dementia Rating (CDR), and CogMate™ digital cognitive tests. Participants were classified into cognitively normal and cognitively impaired groups according to CDR status. Group differences, Spearman rank correlations, and receiver operating characteristic curve analyses were performed.

Results

Among 250 participants, 195 were classified as CDR = 0 and 55 as CDR ≥ 0.5. Cognitive impairment was significantly associated with older age and lower educational level. Participants with CDR ≥ 0.5 had significantly lower scores on MMSE, MoCA, reverse-scored AD8, CogMate™ memory, and CogMate™ attention. MoCA and MMSE showed the highest AUC values, both 0.778. MoCA had the highest sensitivity, whereas MMSE had the highest Youden index. CogMate™ memory and attention showed moderate diagnostic performance.

Conclusions

This study provides quantitative evidence supporting the complementary use of multiple cognitive assessment tools. MoCA may be useful for broad initial screening, MMSE may provide a balanced profile for outpatient assessment, CogMate™ may serve as a convenient supplementary digital tool that works together with established cognitive assessments to support early clinical identification of possible cognitive concerns, and AD8 may add informant-based functional information. These findings support a flexible, scenario-based strategy for earlier recognition, timely referral, and clinical management of cognitive impairment.

Trial registration:

Not applicable.

Background

Dementia is a major global public health challenge and an increasingly important clinical issue in aging societies. According to the World Health Organization, approximately 57 million people worldwide were living with dementia in 2021, and nearly 10 million new cases occur each year [1]. Dementia is associated with progressive cognitive decline, impaired daily functioning, increased caregiver burden, and substantial healthcare and social costs. As population aging continues, the demand for timely identification of cognitive impairment is expected to increase further.

Early detection of cognitive impairment is clinically important because it may allow earlier evaluation, risk-factor management, care planning, patient and caregiver education, and timely referral for further diagnostic assessment. The 2024 report of the Lancet standing Commission emphasized the continuing importance of dementia prevention, intervention, and care, highlighting that dementia should be approached not only as a late-stage neurodegenerative condition but also as a clinical and public health priority requiring earlier recognition and integrated management [2]. Therefore, feasible and accurate cognitive screening strategies are essential for identifying individuals who may benefit from further assessment or intervention.

Cognitive impairment exists along a clinical continuum, ranging from subtle cognitive changes to clinically apparent dementia, with mild cognitive impairment representing an evolving intermediate clinical construct between normal cognitive aging and dementia [3]. In routine clinical practice, early-stage cognitive impairment may be difficult to recognize because symptoms can be mild, fluctuating, or misattributed to normal aging. Screening tools are therefore widely used in community, primary care, and specialist settings. However, the clinical value of a screening tool depends not only on its overall diagnostic accuracy, but also on how well its characteristics match the intended medical scenario. For example, large-scale community screening may prioritize sensitivity and feasibility, whereas outpatient diagnostic evaluation may require a more balanced trade-off between sensitivity and specificity.

Several cognitive assessment tools are commonly used in clinical practice, and systematic comparisons have shown that brief cognitive tests differ in their diagnostic accuracy and clinical suitability across dementia and mild cognitive impairment screening contexts [4]. The Mini-Mental State Examination (MMSE) is one of the most established global cognitive screening instruments and remains familiar to clinicians because of its simplicity and long history of use [5]. The Montreal Cognitive Assessment (MoCA) was developed as a brief screening tool for mild cognitive impairment and includes broader cognitive domains, including executive function, attention, language, memory, and visuospatial ability [6]. In contrast to performance-based cognitive tests, the Ascertain Dementia 8-item Informant Questionnaire (AD8) provides informant-based information regarding changes in daily cognitive and

functional abilities and may complement objective test performance [7]. More recently, digital cognitive assessment tools have gained attention because they may provide scalable, repeatable, and domain-specific cognitive measurements, with potential utility in both clinical screening and longitudinal monitoring [8–10].

Although these tools are widely used, their roles are not interchangeable. Different instruments may emphasize different aspects of cognitive function, differ in administration burden, and show different sensitivity-specificity profiles. Performance-based tests may be influenced by age, educational level, language, testing environment, and familiarity with test formats. Informant-based tools may better capture functional change but depend on the availability and reliability of informant observations. Digital tools may provide standardized and repeatable assessment and may reduce some administrative barriers, but their clinical positioning requires further quantitative evaluation [8–10]. Therefore, clinicians need evidence that clarifies not only whether each tool is useful, but also how different tools may be selected and combined in real-world medical settings.

The key clinical question is not whether a single cognitive screening tool should replace all others, but how different tools can be used effectively and accurately according to different healthcare scenarios. A highly sensitive tool may be useful for broad community screening to reduce missed cases. A tool with better balance between sensitivity and specificity may be more appropriate for outpatient assessment and clinical decision support. Digital cognitive assessment may provide additional value for domain-specific evaluation, repeated testing, or scalable monitoring. Informant-based assessment may further contribute functional information that cannot be fully captured by direct cognitive testing alone.

Accordingly, this study aimed to provide quantitative evidence for the clinical use of multiple cognitive assessment tools. We compared demographic characteristics and cognitive test performance between participants with normal cognition and those with cognitive impairment defined by Clinical Dementia Rating status [11]. We further examined the correlations among conventional cognitive tests, an informant-based questionnaire, and a digital cognitive assessment tool. Finally, we evaluated the diagnostic performance of these tools using receiver operating characteristic curve analysis. By clarifying the diagnostic profiles and complementary roles of these instruments, this study provides a practical evidence base for clinicians to select and combine cognitive screening tools according to different healthcare contexts, including community screening, outpatient evaluation, and digital cognitive monitoring.

Methods

Study design and participants

This cross-sectional study was conducted as a community-based cognitive screening study between March 2025 and June 2025. Community-dwelling older adults were recruited and underwent structured

cognitive assessment. A total of 250 participants aged 65 years or older were included in the final analysis.

The inclusion criteria were as follows: (1) age 65 years or older; (2) ability to communicate in Mandarin or Taiwanese; (3) ability to complete the cognitive assessment procedures; and (4) willingness to participate in the study and provide written informed consent. The exclusion criteria were as follows: (1) previously diagnosed severe dementia or inability to cooperate with the assessment; (2) severe visual, hearing, or motor impairment that prevented completion of the tests; and (3) acute psychiatric or neurological conditions that could substantially affect cognitive assessment results.

Study procedure

The study procedure consisted of protocol development, institutional review board approval, participant recruitment, cognitive assessment, statistical analysis, and interpretation of findings. After the research protocol was established and approved by the institutional review board, eligible community-dwelling older adults aged 65 years or older were invited to participate. The study purpose and assessment procedures were explained to potential participants, and written informed consent was obtained before participation.

Participants then underwent structured cognitive assessment, including conventional performance-based cognitive screening, informant-based assessment, clinical dementia severity assessment, and digital cognitive testing. The conventional and informant-based assessments included the MMSE (MMSE®; Psychological Assessment Resources [PAR], Inc., Lutz, FL, USA. The Taiwanese authorized version published by the Chinese Behavioral Science Corporation (2025) was administered by qualified personnel), MoCA, AD8, and CDR. Digital cognitive assessment was performed using CogMate™. After completion of all assessments, the collected data were compiled and subjected to statistical analysis.

Clinical Dementia Rating assessment and group definition

The CDR was administered by trained nursing personnel. CDR scores were categorized as follows: 0, no dementia; 0.5, very mild impairment; 1, mild impairment; 2, moderate impairment; and 3, severe impairment. For the present analysis, participants with CDR = 0 were classified as the cognitively normal group, whereas those with CDR ≥ 0.5 were classified as the cognitively impaired group. This grouping was used for between-group comparisons and receiver operating characteristic curve analysis.

Cognitive assessment tools

The MMSE and MoCA raw score were used as conventional performance-based global cognitive screening instruments. AD8 was used as an informant-based questionnaire to assess changes in daily cognitive and functional abilities. Because the standard AD8 raw score is oriented in the opposite

direction from MMSE, MoCA, and CogMate™ scores, the AD8 raw score was reverse-scored before statistical analysis by multiplying the standard raw score by -1 (reverse-scored AD8 = -standard AD8 raw score). This transformation was used to maintain directional consistency across assessment tools, so that higher values consistently indicated better cognitive or functional status. The reverse-scored AD8 was then analyzed together with the other cognitive assessment measures in the statistical software.

CogMate™ was used as the digital cognitive assessment tool in this study. CogMate™ is a web-based digital brain-health self-assessment tool designed to evaluate cognitive performance and increase personal awareness of brain health. It is not a medical device and is not intended to diagnose, prevent, treat, or improve specific diseases or symptoms. CogMate™ is based on the Cogstate Brief Battery™ (CBB), a scientific cognitive function testing framework developed by Cogstate Ltd., and is distributed by Eisai as an Asian multilingual version, including Traditional Chinese for Taiwan [12, 13].

CogMate™ can be administered through a fully online platform using a smartphone, tablet, or personal computer, without requiring installation of a mobile application. The assessment takes approximately 15 minutes to complete and includes four task domains: reaction speed, attention, visual learning, and memory. The system generates attention and memory scores, as well as an overall brain performance index. According to the CogMate™ scoring framework, the average reference score is 25 points, and higher scores indicate better cognitive performance. Scores of 20.0–50.0 are considered within the normal range, scores of 15.0-19.9 are considered borderline, and scores of 0-14.9 are considered below the normal range. In the present study, CogMate™ memory and attention scores were selected for statistical analysis because these domains were directly relevant to cognitive screening and were available in the study dataset. Brain-age estimates and the overall brain performance index were not included in the present analysis.

Statistical analysis

Categorical variables were presented as numbers and percentages. Group differences in categorical variables, including age group and educational level, were examined using Pearson's chi-square test. Continuous variables were examined for distributional characteristics. Because the cognitive assessment scores were not normally distributed, they were presented as medians with interquartile ranges and compared between groups using the Mann-Whitney U test. The standardized test statistic was reported as the Z value.

Spearman rank correlation analysis was used to evaluate the associations among MoCA, MMSE, CogMate™ attention, CogMate™ memory, CDR, and reverse-scored AD8. Receiver operating characteristic curve analysis was performed to evaluate the ability of each cognitive assessment tool to distinguish participants with normal cognition from those with cognitive impairment, with reporting guided by principles for diagnostic accuracy studies [14]. The reverse-scored AD8 variable was entered into the statistical analyses in the same direction as the other cognitive measures, with higher values indicating better cognitive or functional status. CDR = 0 was used as the cognitively normal reference group,

whereas CDR ≥ 0.5 was classified as the cognitively impaired group. The area under the curve, 95% confidence interval, optimal cut-off value, sensitivity, specificity, and Youden index were calculated. The optimal cut-off value was determined using the maximum Youden index.

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). A two-sided p value < 0.05 was considered statistically significant.

Use of artificial intelligence-assisted technologies

During the preparation of this manuscript, the authors used ChatGPT for language editing and manuscript formatting support. The authors reviewed and approved all content and take full responsibility for the final manuscript.

Ethical considerations

This study was approved by the Institutional Review Board of Tungs' Taichung MetroHarbor Hospital (approval number 113048). Written informed consent was obtained from all participants before study participation. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Participant characteristics and group comparisons

A total of 250 participants were included in this study. Among them, 195 participants (78.0%) were classified as CDR = 0, representing the cognitively normal group, whereas 55 participants (22.0%) were classified as CDR ≥ 0.5, representing the cognitively impaired group. The demographic characteristics and cognitive assessment scores of the participants are summarized in Table 1.

Table 1
Participant demographic characteristics and cognitive assessment scores by CDR group (N = 250)

Variables	CDR = 0 (n = 195)	CDR ≥ 0.5 (n = 55)	Test statistic	P value
Demographic characteristics, n (%)				
Age group			$\chi^2 = 47.942$	< 0.001
65–74 years	128 (92.8%)	10 (7.2%)		
75–84 years	58 (65.9%)	30 (34.1%)		
≥ 85 years	9 (37.5%)	15 (62.5%)		
Educational level			$\chi^2 = 13.738$	0.001
Illiterate	19 (57.6%)	14 (42.4%)		
Elementary school	86 (75.4%)	28 (24.6%)		
Junior high school	90 (87.4%)	13 (12.6%)		
Cognitive assessment tools, median (IQR)				
MMSE	27.0 (4.0)	22.0 (6.0)	Z = -6.326	< 0.001
MoCA raw score	23.0 (8.0)	14.0 (10.0)	Z = -6.306	< 0.001
AD8, reverse-scored	0.0 (1.0)	-2.0 (2.0)	Z = -4.182	< 0.001
CogMate™ memory	21.6 (8.3)	17.5 (5.1)	Z = -5.307	< 0.001
CogMate™ attention	17.2 (7.8)	13.1 (9.0)	Z = -4.324	< 0.001

Notes: Categorical variables are presented as number (percentage) and were compared using Pearson's chi-square test. Continuous variables are presented as median (interquartile range) and were compared using the Mann-Whitney U test because they were not normally distributed. The Z value indicates the standardized test statistic. AD8 was reverse-scored as -standard AD8 raw score; therefore, higher reverse-scored AD8 values indicate better informant-reported cognitive or functional status, whereas lower values indicate greater decline. CogMate™ scores are interpreted according to the following reference ranges: 20.0–50.0, normal range; 15.0-19.9, borderline range; and 0-14.9, below the normal range. Higher scores indicate better cognitive performance.

Significant differences were observed between the two groups in both age and educational level. The proportion of participants with cognitive impairment increased significantly with age. Cognitive impairment was observed in 7.2% of participants aged 65–74 years, 34.1% of those aged 75–84 years, and 62.5% of those aged 85 years or older ($\chi^2 = 47.942$, $p < 0.001$). Educational level was also significantly associated with cognitive status ($\chi^2 = 13.738$, $p = 0.001$). Participants who were illiterate had the highest proportion of cognitive impairment (42.4%).

Because the cognitive test scores were not normally distributed, continuous variables were presented as medians with interquartile ranges and compared using the Mann-Whitney U test. Participants in the CDR ≥ 0.5 group had significantly lower scores across all cognitive assessments than those in the CDR = 0 group. The median MMSE score was 27.0 in the CDR = 0 group and 22.0 in the CDR ≥ 0.5 group ($Z = -6.326$, $p < 0.001$). The median MoCA raw score was 23.0 and 14.0, respectively ($Z = -6.306$, $p < 0.001$). For the reverse-scored AD8, the median score was 0.0 in the CDR = 0 group and − 2.0 in the CDR ≥ 0.5 group ($Z = -4.182$, $p < 0.001$). Similarly, CogMate™ memory and attention scores were significantly lower in the CDR ≥ 0.5 group. The median memory score was 21.6 in the CDR = 0 group and 17.5 in the CDR ≥ 0.5 group ($Z = -5.307$, $p < 0.001$), whereas the median attention score was 17.2 and 13.1, respectively ($Z = -4.324$, $p < 0.001$).

Correlations among cognitive assessment tools

Spearman rank correlation analysis was conducted to examine the associations among cognitive assessment tools and clinical dementia severity as measured by the CDR. The correlation matrix is shown in Table 2.

Table 2
Spearman correlation matrix of cognitive assessment measures (N = 250)

Measure	MoCA	MMSE	CogMate™ attention	CogMate™ memory	CDR	AD8 reverse-scored
MoCA	1	0.735**	0.504**	0.457**	-0.395**	0.466**
MMSE	0.735**	1	0.376**	0.348**	-0.403**	0.416**
CogMate™ attention	0.504**	0.376**	1	0.178**	-0.264**	0.288**
CogMate™ memory	0.457**	0.348**	0.178**	1	-0.332**	0.271**
CDR	-0.395**	-0.403**	-0.264**	-0.332**	1	-0.276**
AD8 reverse-scored	0.466**	0.416**	0.288**	0.271**	-0.276**	1

Notes: Values are Spearman rank correlation coefficients (rs). Double asterisks indicate that the correlation is significant at the 0.01 level, two-tailed. AD8 was reverse-scored as -standard AD8 raw score so that higher values indicate better informant-reported cognitive or functional status

Most cognitive measures showed significant positive correlations with one another. The strongest correlation was observed between MoCA and MMSE ($rs = 0.735$, $p < 0.001$), indicating a high level of consistency between these two global cognitive measures. MoCA was also moderately correlated with CogMate™ attention ($rs = 0.504$, $p < 0.001$) and CogMate™ memory ($rs = 0.457$, $p < 0.001$). MMSE showed significant positive correlations with CogMate™ attention ($rs = 0.376$, $p < 0.001$) and CogMate™ memory ($rs = 0.348$, $p < 0.001$).

CDR was significantly and negatively correlated with all cognitive assessment scores, including MMSE ($rs = -0.403$, $p < 0.001$), MoCA ($rs = -0.395$, $p < 0.001$), CogMate™ memory ($rs = -0.332$, $p < 0.001$), and CogMate™ attention ($rs = -0.264$, $p < 0.001$). These findings indicate that lower cognitive test performance was associated with greater clinical dementia severity. After reverse scoring, AD8 showed significant positive correlations with MoCA, MMSE, CogMate™ attention, and CogMate™ memory ($rs = 0.271$ to $.466$, all $p < 0.001$), and a significant negative correlation with CDR ($rs = -0.276$, $p < 0.001$). These results support the convergent validity of the cognitive assessment tools used in this study.

Diagnostic performance of cognitive screening tools

Receiver operating characteristic curve analysis was performed to evaluate the ability of each cognitive screening tool to distinguish participants with normal cognition from those with cognitive impairment. CDR = 0 was defined as the cognitively normal group, whereas CDR ≥ 0.5 was defined as the cognitively impaired group. The ROC curves are shown in Fig. 1, and the diagnostic performance indices are summarized in Table 3.

Table 3
Diagnostic performance of cognitive screening tools

Assessment tool	AUC	95% CI	Cut-off	Sensitivity (%)	Specificity (%)	Youden index
MoCA raw score	0.778	0.704–0.852	≤ 21.5	85.5	56.9	0.424
MMSE	0.778	0.709–0.847	≤ 24.5	70.9	75.4	0.463
CogMate™ memory	0.734	0.662–0.807	≤ 19.25	69.1	65.6	0.347
CogMate™ attention	0.691	0.611–0.771	≤ 14.85	61.8	70.3	0.321
AD8 reverse-scored	0.673	0.589–0.757	≤-0.50	56.4	76.4	0.328

Notes: CDR = 0 was used as the cognitively normal reference group, whereas CDR ≥ 0.5 was classified as the cognitively impaired group. The optimal cut-off value was determined using the maximum Youden index. AD8 was reverse-scored as -standard AD8 raw score to align its direction with the other cognitive measures; therefore, lower reverse-scored AD8 values indicate greater informant-reported decline. For the reverse-scored AD8, a cut-off value of ≤-0.50 approximately corresponds to a standard AD8 raw score of ≥ 1.

The area under the curve values ranged from 0.673 to 0.778, indicating moderate to acceptable discriminatory performance. MoCA raw score and MMSE had the highest AUC values, both at 0.778. For MoCA raw score, the optimal cut-off value was ≤ 21.5, with a sensitivity of 85.5%, specificity of 56.9%, and Youden index of 0.424. For MMSE, the optimal cut-off value was ≤ 24.5, with a sensitivity of 70.9%, specificity of 75.4%, and the highest Youden index of 0.463.

CogMate™ memory demonstrated an AUC of 0.734, with an optimal cut-off value of ≤ 19.25, sensitivity of 69.1%, specificity of 65.6%, and Youden index of 0.347. CogMate™ attention had an AUC of 0.691, with an optimal cut-off value of ≤ 14.85, sensitivity of 61.8%, specificity of 70.3%, and Youden index of 0.321. The reverse-scored AD8 had an AUC of 0.673, with an optimal cut-off value of ≤-0.50, sensitivity of 56.4%, specificity of 76.4%, and Youden index of 0.328.

Overall, MoCA showed the highest sensitivity for detecting cognitive impairment, suggesting its potential utility as an initial screening tool. MMSE demonstrated the best balance between sensitivity and specificity, as reflected by the highest Youden index. CogMate™ memory and attention showed moderate diagnostic performance and may serve as supplementary digital cognitive assessment tools.

Discussion

This study provides quantitative evidence for the clinical use of multiple cognitive assessment tools in identifying cognitive impairment. By comparing conventional cognitive screening instruments, an informant-based questionnaire, and a digital cognitive assessment tool, this study demonstrates that different tools offer distinct diagnostic strengths. Rather than supporting a single universal instrument for all clinical settings, our findings suggest that cognitive screening may be optimized by selecting and combining assessment tools according to the intended clinical purpose, such as large-scale community screening, outpatient evaluation, or longitudinal digital monitoring.

The present study showed that participants with cognitive impairment, defined as CDR ≥ 0.5, had significantly lower scores across all cognitive measures, including MMSE, MoCA, reverse-scored AD8, CogMate™ memory, and CogMate™ attention. These findings support the overall validity of these instruments in reflecting clinically meaningful differences in cognitive function. The CDR has been widely used to characterize the presence and severity of cognitive impairment in clinical and research settings [11]. Therefore, the consistent differences observed across multiple tools in relation to CDR status support the clinical relevance of these measures in the present study.

In addition, the proportion of cognitive impairment increased markedly with age and was higher among participants with lower educational attainment. This finding is clinically important because demographic factors may influence cognitive screening performance and interpretation. Previous studies have shown that MMSE scores are affected by age, education, and cultural background [15], and population-based normative data also indicate that MMSE performance varies substantially according to age and educational level [16]. Similar concerns have been reported for MoCA, for which population-based and Taiwan-specific normative studies emphasize the importance of age- and education-sensitive interpretation [17, 18]. These findings suggest that cognitive screening results should not be interpreted solely by a universal cut-off value, particularly in older adults or individuals with limited formal education. In real-world practice, age and education should be considered when selecting screening tools, interpreting scores, and deciding whether further diagnostic evaluation is required.

A key strength of this study is that it provides direct comparative evidence regarding the diagnostic characteristics of different cognitive tools. MoCA and MMSE showed the highest overall discriminatory ability, with both instruments achieving an AUC of 0.778. However, their clinical profiles differed. MoCA demonstrated the highest sensitivity at the optimal cut-off, suggesting that it may be particularly useful when the clinical priority is to detect as many individuals with possible cognitive impairment as possible. This finding is consistent with the original MoCA validation study, which reported that MoCA was more sensitive than MMSE for detecting mild cognitive impairment [6], and with comparative evidence from Chinese middle-aged and older populations showing differences between MoCA and MMSE in mild cognitive impairment screening [19]. Therefore, MoCA may be particularly valuable in community-based or large-scale screening programs, where missing early cognitive impairment may delay further evaluation, risk-factor management, and care planning.

In contrast, MMSE showed the highest Youden index and a relatively balanced sensitivity and specificity profile. MMSE remains one of the most established and familiar cognitive screening instruments in clinical practice [5, 15]. Although it may be less sensitive than MoCA for subtle cognitive impairment, its simplicity, familiarity, and balanced diagnostic profile may make it useful in outpatient assessment or follow-up evaluation. In clinical contexts where both false positives and false negatives carry practical consequences, MMSE may provide a concise and interpretable measure to support clinical judgment.

The diagnostic performance of CogMate™ memory and attention was moderate, with AUC values of 0.734 and 0.691, respectively. These findings suggest that CogMate™ should not be interpreted as a replacement for conventional cognitive screening tools or as a stand-alone diagnostic test for dementia. However, the present study provides quantitative evidence that CogMate™ results are meaningfully associated with established clinical cognitive assessment tools and CDR-defined cognitive status. Participants with CDR ≥ 0.5 had significantly lower CogMate™ memory and attention scores, and these scores showed significant correlations with MoCA, MMSE, and CDR. Therefore, CogMate™ may be used as a supplementary digital tool that works together with established cognitive assessment methods to support early recognition of possible cognitive concerns.

The clinical value of CogMate™ lies in its convenience and accessibility. Because it is web-based, does not require application installation, can be administered using common digital devices, and can be completed within approximately 15 minutes, CogMate™ may be particularly useful in community-based screening, health checkups, and repeated cognitive monitoring [12, 13]. Recent BMC Geriatrics studies of digital cognitive testing in older adults also support the feasibility, usability, and potential acceptability of digital neurocognitive assessment approaches, while emphasizing the need for validation in defined clinical settings [9, 10]. According to the CogMate™ scoring framework, higher scores indicate better cognitive performance, and scores can be interpreted using predefined reference ranges. Therefore, when attention or memory scores fall within the borderline or below-normal range, CogMate™ may help identify individuals who require further clinical evaluation. In this role, CogMate™ can serve as an accessible front-line supportive tool that complements MoCA, MMSE, AD8, and CDR-based clinical

assessment, facilitating earlier recognition, timely referral, and appropriate clinical management of cognitive impairment.

Beyond diagnostic performance, acceptability and administration experience are also important considerations in cognitive screening for older adults. A recent comparative study of older adults reported that participants had more favorable perceptual experiences with CogMate™ than with the MMSE, particularly when assessments were performed in familiar, less formal settings using nontraditional, game-based interactive tools [20]. This supports the potential role of CogMate™ as a convenient adjunctive tool in community-based cognitive screening for older adults. However, CogMate™ results should still be interpreted together with established cognitive assessment tools and clinical evaluation rather than as diagnostic evidence by themselves.

CogMate™ is a brain-health self-assessment tool based on the Cogstate Brief Battery framework and provides brief, card-based, device-accessible assessment of cognitive performance, including reaction speed, attention, visual learning, and memory-related domains [12, 13]. Although CogMate™ is not positioned as a medical device and should not be used to diagnose dementia by itself, its domain-specific results may help clinicians recognize early cognitive problems or dementia-related manifestations that warrant further clinical evaluation. Previous research has supported the clinical utility of the Cogstate Brief Battery in identifying cognitive impairment in mild cognitive impairment and Alzheimer's disease [21]. In the present study, the value of CogMate™ lies in providing digital and domain-specific information, particularly attention and memory performance, that may complement conventional global screening tools such as MoCA and MMSE.

The reverse-scored AD8 showed a lower AUC than MoCA, MMSE, and CogMate™ memory, but it had relatively high specificity. Because AD8 is informant-based and reflects changes in daily cognitive and functional abilities, it provides information that differs from performance-based cognitive testing. The original AD8 study reported that AD8 is a brief and sensitive informant interview for differentiating nondemented and demented individuals and suggested that combining AD8 with brief participant assessment may improve diagnostic accuracy in general practice [7]. In community settings, Chinese and international studies have also shown that AD8 can contribute to dementia and mild cognitive impairment screening when combined with brief performance-based measures, although its ability to distinguish MCI from normal cognition may vary by population and setting [22, 23]. In clinical practice, AD8 may therefore be particularly useful when functional decline is suspected, when an informant is available, or when patient test performance may be affected by education, anxiety, sensory limitations, or testing conditions.

The correlation analysis further supports the convergent validity of these tools. MoCA and MMSE were strongly correlated, indicating that both instruments capture overlapping aspects of global cognitive function. Moderate correlations between CogMate™ subtests and conventional cognitive tests suggest that digital memory and attention measures are related to, but not identical with, traditional screening tools. This distinction is clinically meaningful because digital tests may provide domain-specific

information that is not fully represented by global cognitive scores. Furthermore, the negative correlations between CDR and all cognitive assessment scores indicate that poorer test performance was associated with greater clinical dementia severity. These findings support the clinical relevance of the assessment tools examined in this study.

From a clinical implementation perspective, the main contribution of this study is not merely to identify which tool had the highest AUC, but to clarify how different tools may be used strategically in different medical scenarios. For community-based screening, a high-sensitivity tool such as MoCA may be preferred as the first-line instrument to reduce the risk of missing individuals with possible cognitive impairment. For outpatient clinical assessment, MMSE may be useful because of its familiarity and balanced sensitivity-specificity profile. For individuals requiring more detailed cognitive profiling or repeated follow-up, CogMate™ may provide additional digital and domain-specific assessment value. AD8 may further complement these tools by incorporating informant-based functional observations.

Therefore, this study supports a scenario-based approach to cognitive assessment. Instead of relying on a single screening tool, clinicians may combine tools according to the clinical goal: MoCA for broad initial detection, MMSE for balanced clinical assessment, CogMate™ for convenient digital and domain-specific support, and AD8 for functional and informant-based information. This flexible combination strategy may improve the efficiency and precision of cognitive screening in real-world healthcare settings. It also provides a practical quantitative basis for clinicians to tailor cognitive screening strategies according to setting, resources, and clinical purpose, thereby facilitating earlier recognition, timely referral, and appropriate clinical management of cognitive impairment.

Several limitations should be acknowledged. First, this was a cross-sectional analysis, and therefore the ability of these tools to predict future cognitive decline could not be assessed. Second, cognitive impairment was classified using CDR status, and the results should not be interpreted as equivalent to a definitive etiological diagnosis of dementia. Third, the optimal cut-off values identified in this study may be influenced by the demographic characteristics of the study population, including age and educational level. Because previous studies have shown that cognitive test performance varies by age and education [15–18], external validation in independent cohorts is required before these cut-off values can be broadly generalized. Fourth, although CogMate™ showed moderate diagnostic performance, it is a non-medical digital self-assessment tool, and further studies are needed to determine its longitudinal reliability, usability, and clinical utility in different care settings. Finally, this study did not perform age- or education-adjusted multivariable diagnostic modeling, and future studies should examine whether each tool retains independent discriminatory value after adjustment for demographic factors.

Conclusions

This study provides quantitative evidence supporting the complementary use of multiple cognitive assessment tools. MoCA showed the highest sensitivity and may be suitable for broad initial screening, whereas MMSE demonstrated the best overall balance between sensitivity and specificity. CogMate™

memory and attention showed moderate diagnostic performance and were significantly associated with established cognitive assessment tools and CDR-defined cognitive status. Although CogMate™ should not be interpreted as a stand-alone diagnostic test for dementia, the findings support its use as a convenient supplementary digital tool that can work together with conventional clinical assessments to help identify possible cognitive concerns. AD8 may further provide informant-based functional information. These findings support a flexible, scenario-based strategy in which clinicians select and combine cognitive assessment tools according to the specific clinical context and screening objective, thereby facilitating earlier recognition, timely referral, and appropriate clinical management of cognitive impairment.

Abbreviations

AD8
Ascertain Dementia 8-item Informant Questionnaire
AUC
area under the receiver operating characteristic curve
CBB
Cogstate Brief Battery
CDR
Clinical Dementia Rating
CI
confidence interval
IQR
interquartile range
MMSE
Mini-Mental State Examination
MoCA
Montreal Cognitive Assessment
ROC
receiver operating characteristic
SPSS
Statistical Package for the Social Sciences.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Tungs' Taichung MetroHarbor Hospital (approval number 113048). Written informed consent was obtained from all participants before study participation. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

The authors received no specific funding for this work.

Author Contribution

HCC and MHH contributed equally to this work and share first authorship. SCH conceived the study, developed the study concept, and supervised the project. HCC and MHH contributed to participant recruitment, investigation, data collection, data curation, and formal analysis. YCC drafted the manuscript and contributed to critical review and editing. CYH contributed to data organization and participated in conceptual discussion. YCC and SCH contributed equally as co-corresponding authors. All authors read and approved the final manuscript.

Acknowledgement

The authors thank Tungs' Taichung MetroHarbor Hospital and the Dementia Center for their administrative and logistical assistance.

Data Availability

The datasets used and analysed during the current study are not publicly available because they contain participant-level research data, but are available from the corresponding author on reasonable request and subject to applicable institutional and ethical requirements.

References

1. World Health Organization. Dementia. 2025. https://www.who.int/news-room/fact-sheets/detail/dementia. Accessed 15 Jun 2026.
2. Livingston G, Huntley J, Liu KY, Costafreda SG, Selbæk G, Alladi S, et al. Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. Lancet. 2024;404(10452):572–628. 10.1016/S0140-6736(24)01296-0.

3. Petersen RC, Caracciolo B, Brayne C, Gauthier S, Jelic V, Fratiglioni L. Mild cognitive impairment: a concept in evolution. J Intern Med. 2014;275(3):214–28. 10.1111/joim.12190.
4. Tsoi KKF, Chan JYC, Hirai HW, Wong SYS, Kwok TCY. Cognitive tests to detect dementia: a systematic review and meta-analysis. JAMA Intern Med. 2015;175(9):1450–8. 10.1001/jamainternmed.2015.2152.
5. 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(3):189–98. 10.1016/0022-3956(75)90026-6.
6. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53(4):695–9. 10.1111/j.1532-5415.2005.53221.x.
7. Galvin JE, Roe CM, Powlishta KK, Coats MA, Muich SJ, Grant E, et al. The AD8: a brief informant interview to detect dementia. Neurology. 2005;65(4):559–64. 10.1212/01.wnl.0000172958.95282.2a.
8. Ding Z, Lee TL, Chan AS. Digital cognitive biomarker for mild cognitive impairments and dementia: a systematic review. J Clin Med. 2022;11(14):4191. 10.3390/jcm11144191.
9. Amirpour A, Eckerblad J, Bergman LM, Nilsson U. Comparing analog and digital neurocognitive tests with older adults: a study of the ISPOCD battery vs. a digital test battery from Mindmore. BMC Geriatr. 2024;24:34. 10.1186/s12877-023-04648-w.
10. Batista ITP, Queiroz KM, Souza Menezes CE, Peixoto Junior AA, Marçal E. Development of a digital memory and learning test for elderly individuals. BMC Geriatr. 2025;25:3. 10.1186/s12877-024-05421-3.
11. Morris JC. The Clinical Dementia Rating: current version and scoring rules. Neurology. 1993;43(11):2412–4. 10.1212/wnl.43.11.2412-a.
12. Eisai Taiwan Inc. CogMate™ official website. https://cogmate.tw/. Accessed 15 Jun 2026.
13. Eisai Co., Ltd. Eisai to launch digital tool CogMate™ in Taiwan and Hong Kong for self-assessment of brain performance (brain health). 2022. https://www.eisai.com/news/2022/news202202.html. Accessed 15 Jun 2026.
14. Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig L, et al. STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. BMJ. 2015;351:h5527. 10.1136/bmj.h5527.
15. Tombaugh TN, McIntyre NJ. The Mini-Mental State Examination: a comprehensive review. J Am Geriatr Soc. 1992;40(9):922–35. 10.1111/j.1532-5415.1992.tb01992.x.
16. Crum RM, Anthony JC, Bassett SS, Folstein MF. Population-based norms for the Mini-Mental State Examination by age and educational level. JAMA. 1993;269(18):2386–91. 10.1001/jama.1993.03500180078038.
17. Rossetti HC, Lacritz LH, Cullum CM, Weiner MF. Normative data for the Montreal Cognitive Assessment (MoCA) in a population-based sample. Neurology. 2011;77(13):1272–5.

10.1212/WNL.0b013e318230208a.

18. Cheng YH, Lee SC, Chen YC, Chen JH, Yu RL, Lee WJ, et al. Normative study of the Taiwanese version of the Montreal Cognitive Assessment (MoCA) in community-dwelling individuals in Taiwan. J Chin Med Assoc. 2025;88(8):617–23. 10.1097/JCMA.0000000000001265.
19. Jia X, Wang Z, Huang F, Su C, Du W, Jiang H, et al. A comparison of the Mini-Mental State Examination (MMSE) with the Montreal Cognitive Assessment (MoCA) for mild cognitive impairment screening in Chinese middle-aged and older population: a cross-sectional study. BMC Psychiatry. 2021;21:485. 10.1186/s12888-021-03495-6.
20. Chuang HC, Huang SC, Chang YJ. A comparative study on the perceptual experiences of older individuals with CogMate™ and Mini-Mental State Examination cognitive function assessments. Tungs Med J. 2025;19(2):115–23. 10.4103/etmj.etmj-d-25-00002.
21. Maruff P, Lim YY, Darby D, Ellis KA, Pietrzak RH, Snyder PJ, et al. Clinical utility of the Cogstate Brief Battery in identifying cognitive impairment in mild cognitive impairment and Alzheimer's disease. BMC Psychol. 2013;1:30. 10.1186/2050-7283-1-30.
22. Wang Y, Liu T, Cai Y, Wu Y, Nie Y, Kuang W, et al. The Chinese version of informant AD8 for mild cognitive impairment and dementia screening in community-dwelling older adults. Public Health Nurs. 2023;40(2):258–65. 10.1111/phn.13166.
23. Razavi M, Tolea MI, Margrett J, Martin P, Oakland A, Tscholl DW, Galvin JE. Comparison of two informant questionnaire screening tools for dementia and mild cognitive impairment: AD8 and IQCODE. Alzheimer Dis Assoc Disord. 2014;28(2):156–61. 10.1097/WAD.0000000000000008.

Figures

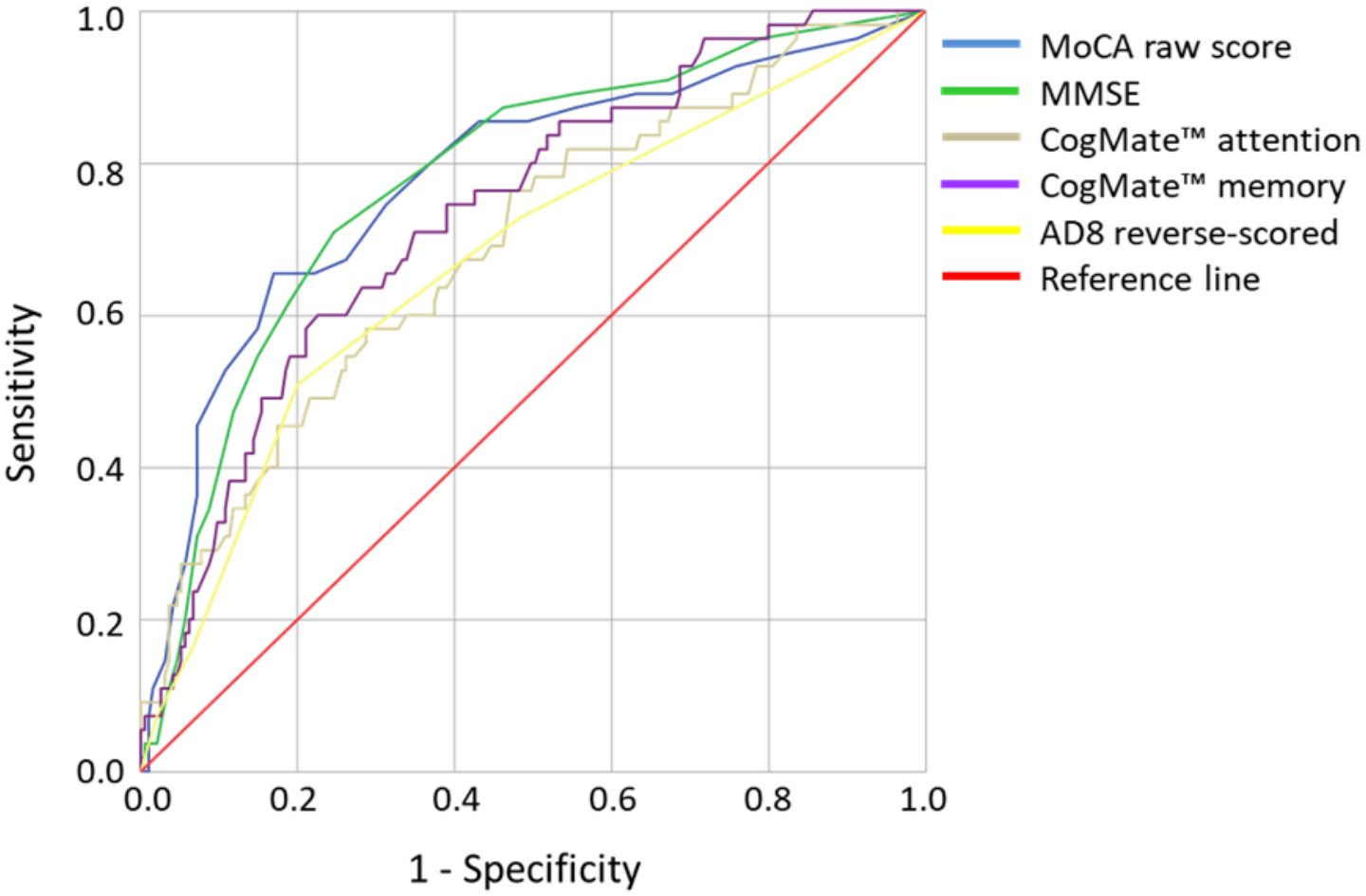


Figure 1

ROC curves by CDR status.

The ROC curves are shown for the MoCA raw score, MMSE, CogMate™ attention, CogMate™ memory, and reverse-scored AD8. The X-axis represents 1 - specificity, and the Y-axis represents sensitivity.