

ADAS-Cog Performance in Urban Indian Patients with Alzheimer's Disease: Implications for Culturally Appropriate Cognitive Assessment

Abstract

Background:

The Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-Cog) plays an important role in determining cognitive impairment associated with Alzheimer's disease (AD); however, there could be several factors that influence its proper functioning. The current study examined the scale's performance in the Indian population and tested the newly developed Indian word list.

Methods:

The unmatched case-control study included 170 people, among which there were 85 clinically diagnosed patients with AD and 85 mentally healthy individuals from the tertiary care setting of Indian neurology. Patients' AD severity was assessed only by the neurologist without regard to ADAS-Cog scores received. Patients participated in only one ADAS-Cog assessment, administered in their native language whenever possible. A culturally and linguistically adjusted Indian ten-word list was used for two components of the Word Recall and Word Recognition tests. The Content Validity Index (CVI) tested the content validity of the ADAS-Cog while the credibility of the instrument was confirmed by Cronbach's alpha coefficient.

Results:

Results showed that patients with AD had significantly higher ADAS-Cog total scores than normal controls (median [IQR], 27.0 [20.0–36.5] vs 7.0 [3.0–10.0]; $r = 0.836$; $p < 0.001$). All 11 domains of the ADAS-Cog test were significantly less successful in AD after Holm adjustment ($r = 0.396$ to 0.592). In addition, the ADAS-Cog scores were increasing for the patients from the mild to moderate and severe levels (median, 20.0, 29.5, and 40.0 respectively; $\eta^2H \approx 0.617$; $p < 0.001$). The adapted scale had the CVI equal to 1.00 while the Cronbach's alpha coefficient of the instrument was equal to 0.853. The comparison of the ADAS-Cog scores of the two groups (with and without a word list) yielded the following values: median = 27.5 vs 8.0; $r = 0.849$. The ROC analysis yielded an area under the ROC curve of 0.984 (95% CI, 0.969–0.999) for the whole sample and 0.992 for the Indian word list user subgroup.

Conclusion:

The results of the ADAS-Cog test showing a notable distinction between clinically diagnosed patients with AD and cognitively normal elderly individuals and being linked to clinical severity have been confirmed on the basis of the use of culturally adapted Indian word lists, which also proved to be clinically relevant for the described group. However, the current study demonstrates the clinical applicability of the results without full cross-cultural validation. Thus, more extensive studies across several languages, with formal cross-cultural validation of psychometric properties, are necessary.

Keywords

Alzheimer's disease; ADAS-Cog; cognitive assessment; cultural adaptation; Indian word list; cognitive impairment; psychometric evaluation; diagnostic discrimination; linguistic adaptation; India

INTRODUCTION

The most prevalent cause of dementia is Alzheimer's disease (AD), and it has lately turned into a rising public health issue with the ever-increasing ageing of the population. The challenge is particularly significant in India due to the large number of dementia patients across various regions of the country, where data is inconsistent. Data from national surveys show dementia affects a large part of Indian population, while data from systematic reviews emphasize discrepancies among findings from various research centers and countries (1,2). The global prediction is that the number of dementia cases will increase sharply in the coming decades, thus creating an obvious demand for reliable and accessible methods of cognitive assessment (2). The most recent technologies used to diagnose AD rely on a combination of clinical and psychological assessments conducted as part of a single diagnostic method (3,4).

Cognitive assessment is of high relevance for diagnosis of dementia in patients undergoing various procedures. The most widely used instrument for cognitive assessment is the Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-Cog) test which has had a long path of development. Initially designed as part of a larger test of cognitive impairment in AD, such as the ADAS-Cog, the test is intended to assess multiple cognitive domains (5). Numerous studies have confirmed the methodology's validity and consistency, leading to its widespread use in research (6). The test includes various aspects of cognitive impairment such as memory, language, praxis, orientation and comprehension and the higher score means more cognitive impairment in AD patients.

The ADAS-Cog is a widely used tool in the field of study; however, it is not truly psychometrically reliable. Studies that have examined different scales show that subscales can differ from one another; thus, they measure cognitive processes differently and contribute different shares to the overall score (7–9). Psychometric studies have raised a question of whether the total score can always be seen as the same value of cognitive impairment since the different scales of the tool are characterized by different measurement properties (9,10). In addition, the studies have focused on the quality of ADAS-Cog scores across repeated evaluations and in clinical trials, and the outcomes of these analyses have revealed the importance of understanding the instrument's features and the properties of its different components before interpretation (11–14).

Language, level of education, and experience with similar situations are very important when evaluating an individual using psychological tests. The importance of the issue is particularly high for countries with high linguistic and cultural diversity. In India for instance, cognitive assessment will have to take into consideration the presence of a number of languages and cultural differences which may influence the assessment process. Results from Indian studies indicate that the adaptation and validation of cognitive assessment tools are necessary in

culturally diverse settings (15–18). Broader systematic evidence indicates that cognitive assessment tools that are compatible with cultural and linguistic requirements are also necessary sources of information to help reduce potential measurement bias in diverse populations (19).

The adaptation of the ADAS-Cog has already been considered from a cultural perspective in line with Indian standards, as evidenced by research by Lakshminarayanan et al. on different variants of the ADAS-Cog for use in India. Researchers explored a Tamil version of the tool, adapted to South Indian culture, which allowed them to demonstrate the feasibility and relevance of such adaptation to the linguistic and cultural context of its use (20). This work consequently may serve as a basis for culturally appropriate usage of the ADAS-Cog in India. Nonetheless, it should be mentioned that the country is distinctive for significant linguistic and cultural differences; thus, the results of one linguistic and/or regional population cannot be generalized and applied to any other one. The use of the results obtained with the help of other Indian cognitive tests, including ICMR Neurocognitive Toolbox or multilingual versions of more well-known cognitive assessment tools proves the necessity to account for linguistic differences while evaluating cognitive scores of Indian people (15–18).

The ADAS-Cog is known to have its definite role in AD studies, and Indian adaptation of the tool has already experienced some testing, but it is still necessary to gather more data on its functioning in the Indian clinical population. More particularly, the usability of the obtained score as well as separate cognitive domains will help better understand its discriminative properties. In addition, using culturally adapted word lists is crucial, as memory mechanisms may be highly sensitive to the familiarity of the words used for testing. Hence, culturally appropriate evaluation should provide reasonable discrimination between patients suffering from AD and old people with no cognitive problems as well as demonstrate interpretable results throughout the relevant cognitive domains.

Therefore, the present research is significant for evaluating the performance of the ADAS-Cog in an Indian clinical environment by comparing AD patients with cognitively healthy elderly individuals. The study also investigated the ADAS-Cog efficiency at different clinical levels of AD severity together with assessing the working of the culturally adapted Indian word list as compared to the original one. The research also gave consideration to how discriminative the general score of the ADAS-Cog was through using receiver operating characteristic analysis with the aim to investigate the results obtained in the subgroup of participants who experienced only the Indian word list. Thus, the study is expected to contribute to the data on the discriminative efficiency, cultural applicability, and measurement properties of the Indian version of the ADAS-Cog.

METHODS

Study Design and Setting

This observational, unmatched case-control study was conducted in the Neurology Department of Marengo Asia Hospital in Gurugram, Haryana, India. The study examined how well the ADAS-

Cog distinguished between patients clinically diagnosed with AD and cognitively healthy elderly adults. ADAS-Cog's performance was also assessed with respect to clinically designated levels of severity of AD, and the use of a culturally modified Indian word list was also tested. Participants were enrolled from the neurology outpatient clinic at the given hospital in accordance with the pre-established eligibility criteria. Each participant completed one cognitive assessment, and no therapeutic interventions were provided during the study. Ethical approval was obtained from the Institutional Ethics Committee on 29 January 2026, before initiation of participant recruitment (NKPSIMS & RC and LMH/IEC/38/2026).

Participants and Study Groups

Involving 170 participants, consisting of 85 clinically diagnosed patients with AD and 85 cognitively normal controls. An unmatched case-control design was utilized and individual matching by age or sex was not performed. In the AD group, patients were diagnosed with AD by neurologists based on accepted criteria. Since then, AD cases have been further classified as mild, moderate, or severe. The control group consisted of healthy older adults with no diagnosis of cognitive impairment or dementia. The controls were part of the recruited group without individual matching with AD patients.

Sample Size Calculation

For the primary comparison of ADAS-Cog performance between two independent groups, namely patients with AD and the controls with no cognitive impairment, the sample size was determined a priori. Using previously available information on the discriminative ability of ADAS-Cog for Alzheimer's disease and Alzheimer's disease-related cognitive states (21), an expected standardised difference of approximately 0.43 was used in sample size calculations. Considering two-sided alpha of 0.05 and statistical power of 80%, the required sample size was estimated to be approximately 85 subjects per group. Therefore, the study aimed at a total sample size of 170 individuals made up of 85 subjects with AD and 85 control subjects.

Eligibility Criteria

Elderly people who were older than 60, who were able to complete the ADAS-Cog test in the selected language, who had provided written informed consent, and who met the necessary clinical criteria were eligible to participate in the research. Individuals in the AD group were required to have a verified clinical diagnosis of AD given by the physician. The healthy participants did not have any AD diagnosis.

Exclusion criteria included severe visual, hearing, speaking, or mobility problems that would prevent adequate results of ADAS-Cog test; acute delirium; serious mental condition preventing from cognitive testing; unstable condition, reason of which was neurological or medical; finding which was verified that the person did not have Alzheimer's disease; severe behavior difficulties preventing the person from taking the tests; incomplete documentation in relation to the clinical history or ADAS-Cog results.

Clinical Classification of Alzheimer's Disease Severity

The treating neurologist made a clinical determination of severity of the AD and classified it as mild, moderate or severe. Clinical severity classification was made separately from ADAS-Cog assessment. Out of 85 participants with AD, mild AD was classified in 35 patients, 30 patients were assigned to the moderate AD group and 20 patients were classified as having severe AD.

Once the AD has been clinically classified according to the severity, the ADAS-Cog was administered to analyze cognitive performance of patients across the severity groups. Total score of the ADAS-Cog was not used to designate or alter clinical severity classification, which allowed to keep clinical classification separate from cognitive performance.

Study Instrument

The Cognitive assessment was conducted by using the ADAS-Cog, the data was obtained by the ADAS-Cog India data collection form. The form used for the assessment collected the demographic and clinical details, language of assessment, word-list version, the individual scores of the various domains, and total ADAS-Cog score.

There are 11 cognitive domains in the test: Word Recall, Naming Objects and Fingers, Following Commands, Constructional and Ideational Praxes, Orientation, Word Recognition, Remembering the Test Instructions, Spoken Language Ability, Finding Words and the Comprehension of Spoken Language. The total score of the ADAS-Cog ranges from 0 to 70, with higher scores indicating greater cognitive impairment.

Cultural and Linguistic Adaptation

In order to make the ADAS-Cog applicable to Indian context, assessment was conducted in language preferred by the participant to the extent possible. The languages used for assessment were English, Hindi, Marathi, Tamil, Telugu, Bengali, Punjabi and other local languages. The language used for assessment was recorded for each participant and treated as a characteristic of assessment process in the analysis.

For Word Recall and Word Recognition parts, an Indian culturally-appropriate 10-word list was used where possible. The adapted 10-word list was compiled from the words Tulsi, Ganga, Dupatta, Tabla, Rickshaw, Chawl, Marigold, Dhaba, Minaret and Charpoy. Original word list was preserved for comparison but administered only when appropriate.

The evaluation of cultural adaptation of word list was fulfilled thanks to expert evaluation of the content and by comparing the performance of participants according to word list and clinical group. The situation allowed for analyzing the performance of culturally adapted word list among study group without treating the comparison of word lists as equivalence testing.

Evaluation of Validity

A group of five relevant clinical and/or academic specialists assessed the content validity of the culturally adapted testing tools. The specialists evaluated the appropriateness of the material under assessment and its relevance to the specific clinical setting and the population targeted by the investigation. The Content Validity Index (CVI) was 1.00, indicating that the panel experts agreed on the relevance of the evaluated items.

The known-groups validity was assessed by comparing test results with the ADAS-Cog among participants diagnosed with AD and cognitively healthy subjects.

Evaluation of Reliability

The internal consistency of the ADAS-Cog was assessed using Cronbach's alpha across 11 cognitive domains. The overall Cronbach's alpha was 0.853, indicating satisfactory internal consistency in the study sample. Cronbach's alpha was used as an index of the internal reliability of the ADAS-Cog, but it would not measure its test-retest reliability, inter-rater reliability, or diagnostic efficiency.

Data Collection Procedure

Once eligibility and consent have been secured, the information on both demographics as well as clinical aspects was collected using a standardized method of collecting data for the study involved. The ADAS-Cog was then administered by qualified personnel according to standardized methods of administering the test.

The Word Recall aspect involved prospective participants completing three recall tests and the score for the same was obtained by identifying the mean value. All remaining tests that were part of the ADAS-Cog examination were scored using the established methods for administering the tests. The scores obtained from each of the different domains were added together to obtain the overall score using standardized methods of administering the ADAS-Cog.

Outcome Measures

The main outcome variable was the overall ADAS-Cog test result, which was measured in terms of the differences between AD patients and normal mental function individuals. The secondary outcomes comprised all 14 tests of the ADAS-Cog, the degrees of difference in both the total and test-specific measurements between the two groups, and the differences in test results between patients who had been assigned a clinical AD stage.

In addition, the results included the content validity of the culturally adapted ADAS-Cog tests, the internal consistency of the tests, and the differences between group scores on the performance indices of Word Recall and Word Recognition for the initial and Indian-adapted versions of the ADAS-Cog tests. As to those who undertook the Indian version of Word test, the results showed that the AD patients and healthy individuals had different results in terms of this neuropsychological test. Moreover, the authors studied how effective the ADAS-Cog results were in the distinction between patients and people with normal cognitive function using ROC analysis both in the general sample and the participants of the Indian version of the study.

The demographic data included participants' ages, gender, years of schooling, and the version of the Word list used.

Statistical Analysis

The data were analysed using IBM SPSS Statistics. The continuous variables were presented as mean $\pm$ standard deviation along with median (interquartile range) wherever necessary and the

categorical variables as percentages and frequencies. The Shapiro-Wilk test was applied to check for normalization. The between-group comparison of demographic variables was done with independent-samples t-test for normally distributed data with Welch correction, Mann-Whitney test, or chi-square/Fisher's exact test for categorical variables.

The ADAS-Cog total and domain scores were compared for AD cases and cognitively normal controls using the Mann-Whitney U test. The Kruskal-Wallis test was used to compare scores across clinically allocated AD severity categories; pairwise comparisons were conducted using the Mann-Whitney U test where necessary. The effect size was calculated for non-parametric tests. Additionally, Holm's sequential correction was done for multiple comparisons.

Performance on the Indian-adapted and original word lists was compared using the Mann-Whitney U test in the AD and control groups. Further analysis was performed for participants using the Indian-adapted word list to compare AD cases with controls on the ADAS-Cog total score, Word Recall, and Word Recognition.

ROC analysis was performed to assess the discriminative ability of the ADAS-Cog total score in distinguishing AD from cognitively normal controls. The Area under the curve was computed with 95% confidence intervals, sensitivity, specificity and the Youden index. A separate ROC analysis was done in Indian word list subgroup. In the non-parametric analysis using Monte Carlo estimation, 10,000 drawn tables were used. All tests were two-tailed and statistical significance was set at $p < 0.05$.

RESULTS

Demographic and assessment characteristics of the study population

The study comprised of 85 Alzheimer patients and 85 normal participants. The two autism and control groups were largely similar in sex, with Alzheimer patients being older and having less years of formal learning than the controls. The culture specific Indian word list was used for most participants in both groups, while the original ADAS-Cog word list was used sparingly and similarly in both groups. These variables provide necessary background information for comparisons to be performed with ADAS-Cog scores and word-list comparisons (Table 1).

Table 1. Demographic, linguistic, and assessment characteristics of the study population

Variable	AD (n=85)	Cognitively normal controls (n=85)
Age, years, mean $\pm$ SD	77.20 $\pm$ 3.55	75.78 $\pm$ 4.80
Formal education, years, mean $\pm$ SD	14.48 $\pm$ 1.84	15.18 $\pm$ 2.07
Male, n (%)	46 (54.1)	44 (51.8)
Female, n (%)	39 (45.9)	41 (48.2)
Word-list version, n (%)		

Indian culturally adapted	74 (87.1)	74 (87.1)
Original ADAS-Cog	11 (12.9)	11 (12.9)

Table 1 legend: Values are mean $\pm$ SD or n (%), as appropriate. †Welch independent-samples *t*-test; ‡Mann–Whitney *U* test; § χ^2 test.

ADAS-Cog Total Score

ADAS-Cog total scores were markedly higher in participants with AD than in cognitively normal controls (Table 2). The between-group difference was large, with an effect size of $r=0.836$, indicating substantial separation in overall cognitive performance.

Table 2. ADAS-Cog total scores in patients with Alzheimer’s disease and cognitively normal controls

Group	n	Median (IQR)	Mean rank	Mann–Whitney <i>U</i>	<i>Z</i>	<i>p</i> -value	Effect size, <i>r</i>
Alzheimer’s disease	85	27.0 (20.0–36.5)	126.63	116.500	–10.902	<0.001	0.836
Cognitively normal controls	85	7.0 (3.0–10.0)	44.37	—	—	—	—

Table 2 legend: Values are median (IQR) and mean rank. Higher ADAS-Cog scores indicate greater cognitive impairment. Between-group comparison was performed using the Mann–Whitney *U* test; $r=|Z|/\sqrt{N}$.

Domain-wise ADAS-Cog Performance

The results demonstrated that all 11 domains of ADAS-Cog in individuals with AD suffered from significantly greater impairment than in controls (all adjusted $p<0.001$), as shown in Table 3. The most marked differences between the groups were in Word Recognition, Ideational Praxis, Word Recall, and Orientation, while the other measures showed moderate and strong effects. Consequently, the distinction between the groups was observed across measures of memory, orientation, praxis, language, and comprehension, rather than across any of their sub-components.

Table 3. Domain-wise ADAS-Cog scores in Alzheimer’s disease and cognitively normal controls

ADAS-Cog domain	AD, Median	Controls, Median	Mann–Whitney	<i>Z</i>	Holm-adjusted <i>p</i> -	Effect size, <i>r</i>
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	(IQR)	(IQR)	<i>U</i>		value	
Word Recall	4.0 (2.0–7.0)	1.0 (0.0–2.0)	1222.0	–7.579	<0.001	0.582
Naming Objects/Fingers	2.0 (0.0–3.5)	0.0 (0.0–0.0)	1707.5	–6.437	<0.001	0.494
Following Commands	2.0 (1.0–4.0)	0.0 (0.0–1.0)	1762.5	–6.069	<0.001	0.466
Constructional Praxis	1.0 (0.0–3.0)	0.0 (0.0–1.0)	1885.5	–5.780	<0.001	0.443
Ideational Praxis	2.0 (1.0–3.0)	0.0 (0.0–0.0)	1335.5	–7.669	<0.001	0.588
Orientation	3.0 (1.5–6.0)	0.0 (0.0–1.0)	1319.5	–7.410	<0.001	0.569
Word Recognition	3.0 (1.0–6.0)	0.0 (0.0–1.0)	1202.0	–7.723	<0.001	0.592
Remembering Test Instructions	2.0 (0.0–3.0)	0.0 (0.0–0.0)	1941.5	–5.714	<0.001	0.438
Spoken Language Ability	2.0 (1.0–4.5)	0.0 (0.0–1.0)	1600.5	–6.611	<0.001	0.507
Word-Finding Difficulty	1.0 (0.0–3.0)	0.0 (0.0–1.0)	2070.0	–5.174	<0.001	0.397
Comprehension of Spoken Language	1.0 (0.0–3.5)	0.0 (0.0–1.0)	2049.5	–5.166	<0.001	0.396

Table 3 legend: Values are median (IQR). Between-group comparisons used the Mann–Whitney *U* test. Holm correction was applied across 11 domain-level comparisons. Higher scores indicate greater impairment.

ADAS-Cog According to Clinician-assigned AD Severity

Among the 85 participants with Alzheimer’s disease, 35 (41.2%) were diagnosed as mild, while 30 (35.3%) were diagnosed as moderate and 20 (23.5%) were diagnosed as severe according to the neurologist’s findings. The severity classification was not dependent on ADAS-Cog scores. The ADAS-Cog scores showed a progressive increase across the three severity groups. The overall difference was statistically significant with a large effect size and pairwise ANOVA post hoc comparisons confirmed this difference.

Table 4. ADAS-Cog total scores according to clinician-assigned Alzheimer's disease severity

Clinical severity	n (%)	Median (IQR)
Mild AD	35 (41.2)	20.0 (18.0–23.0)
Moderate AD	30 (35.3)	29.5 (23.5–34.75)
Severe AD	20 (23.5)	40.0 (37.5–44.0)

Overall Kruskal–Wallis: $H=52.554$, $df=2$, $p<0.001$; $\eta^2H=0.617$.

Pairwise comparisons: mild vs moderate, $U=144.5$, $r=0.622$; moderate vs severe, $U=80.5$, $r=0.616$; mild vs severe, $U=4.0$, $r=0.818$; Holm-adjusted $p<0.001$ for all comparisons.

ROC Analysis

The ROC analysis showed that the ADAS-Cog total score had very good discrimination between people with AD and cognitively normal individuals (Figure 1). The AUC was 0.984 (95% CI, 0.969–0.999; $p<0.001$). Using a threshold of ≥ 16.5 provided a sensitivity of 91.8% and specificity of 100.0%, while using a threshold of 15.5 provided a sensitivity of 92.9% and a specificity of 97.6%.

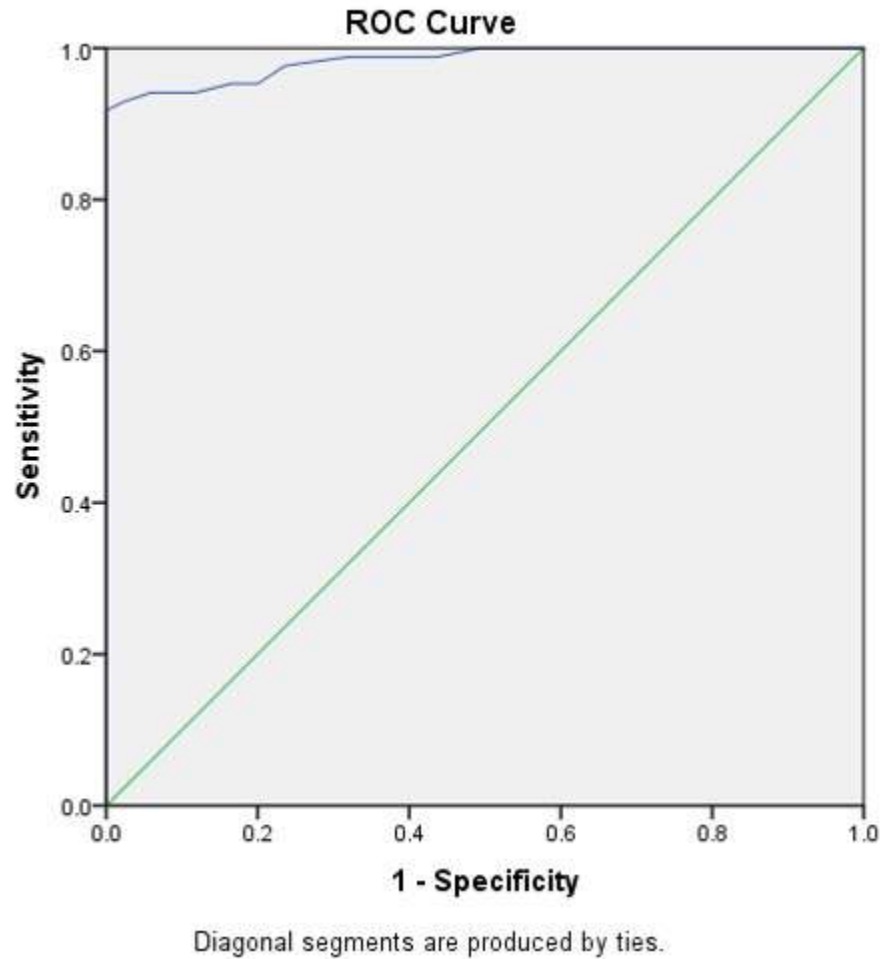


Figure 1. Receiver operating characteristic curve for ADAS-Cog total score

Cultural and Linguistic Adaptation Analysis

Out of the 170 people who were part of the study, 148 (87.1%) had the Indian word list that had been adapted to the local culture. The others, that is 22 people received the non-adapted word list.

In the group that was suffering from early detection of Alzheimer's disease, Word Recall showed no significant differences between word list versions. However, Word Recognition was significantly better for the group that used the culturally adapted list. Neither Word Recall nor Word Recognition showed significant differences among people in the control group (see Table 5). The results indicate that the two versions of the word list did not have the same influence on the two aspects of memory.

Table 5. Comparison of memory-related ADAS-Cog domains according to word-list version

Diagnostic	ADAS-Cog	Indian	Original	Mann–	Z	p-
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group	domain	adapted word list, n=74, Median (IQR)	word list, n=11, Median (IQR)	Whitney <i>U</i>		value
Alzheimer's disease	Word Recall	4.0 (5)	3.0 (5)	340.5	-0.877	0.381
Alzheimer's disease	Word Recognition	3.5 (4)	1.0 (2)	185.5	-2.919	0.004
Cognitively normal controls	Word Recall	1.0 (2)	1.0 (2)	397.0	-0.139	0.889
Cognitively normal controls	Word Recognition	0.0 (1)	0.0 (1)	364.0	-0.633	0.527

Table 5 legend: Values are median (IQR). Comparisons were performed separately within each diagnostic group using the Mann–Whitney *U* test. The original-word-list subgroup comprised 11 participants per diagnostic group.

Performance of the Culturally Adapted Indian Word List

Among the 148 participants who were given the culturally adapted Indian word list, cases of AD had a significantly higher ADAS-Cog total score than controls, with a very large effect size ($r = 0.849$). Also, both the Word Recall and Word Recognition showed very large effects between the two groups ($r = 0.607$ and $r = 0.624$ respectively) (Table 6).

Table 6. ADAS-Cog performance between Alzheimer's disease and cognitively normal controls among participants receiving the culturally adapted Indian word list

Outcome	AD (n=74), Median (IQR)	Controls (n=74), Median (IQR)	Mann–Whitney <i>U</i>	<i>Z</i>	<i>p</i> -value	Effect size, <i>r</i>
ADAS-Cog total score	27.5 (18)	8.0 (7)	46.0	-10.331	<0.001	0.849
Word Recall	4.0 (5)	1.0 (2)	847.0	-7.375	<0.001	0.607
Word Recognition	3.5 (4)	0.0 (1)	807.5	-7.583	<0.001	0.624

Table 6 legend: Values are median (IQR). Analyses were restricted to participants receiving the culturally adapted Indian word list (n=148). Higher scores indicate greater impairment. Between-group comparisons used the Mann–Whitney *U* test.

ROC Analysis in the Culturally Adapted Indian Word-List Subgroup

The results from 148 participants who were exposed to the Indian word list developed especially for the study showed that the ADAS-Cog's total score was able to differentiate between individuals having Alzheimer's from those who are not with an AUC of 0.992 (Figure 2). Using a threshold of ≥ 16.5 delivered 93.2% sensitivity and 100% specificity, whereas a threshold of ≥ 15.5 yielded 94.6% sensitivity and 98.6% specificity.

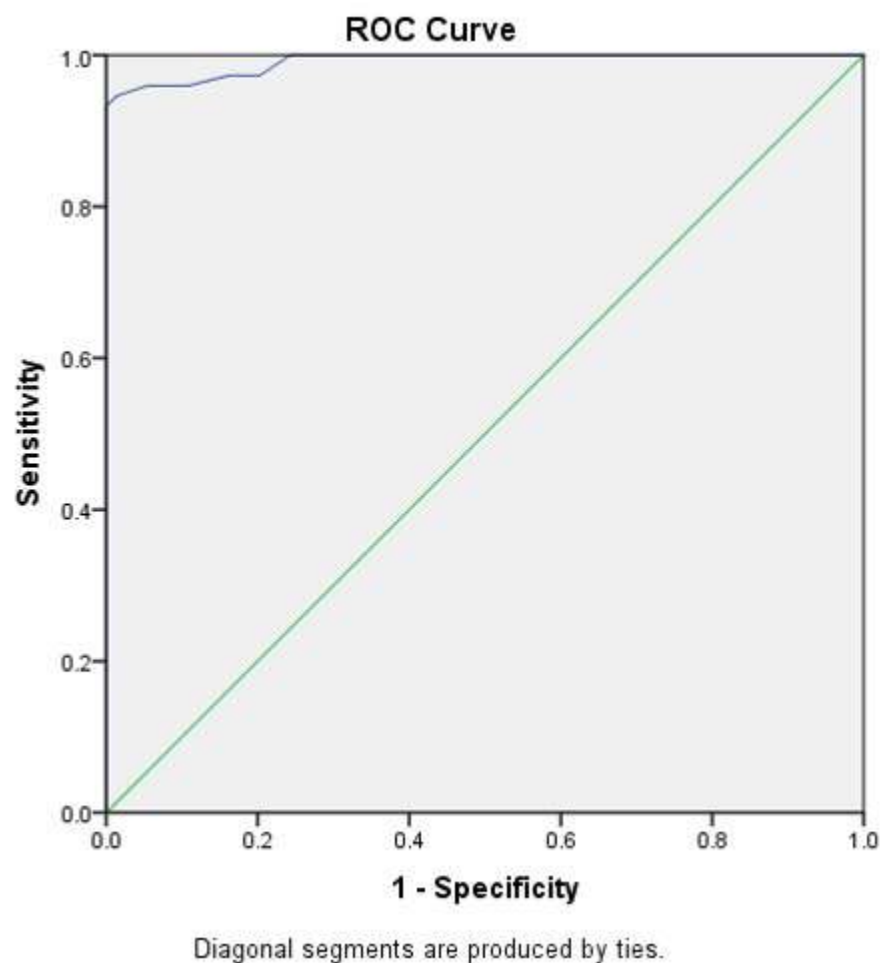


Figure 2. Receiver operating characteristic curve for ADAS-Cog total score among participants receiving the culturally adapted Indian word list

DISCUSSION

The current research assessed the utility of the ADAS-Cog among a sample of Indian patients through an unmatched cohort design, with other measures taken into account such as clinically assessed severity of AD and some alterations made to the original word list for cultural purpose. It was found that there were considerable dissimilarities in the total scores of ADAS-Cog between patients suffering from mentally incurred AD and healthy controls. Given that patients with diagnosed AD received higher scores in comparison to healthy ones, with median totals of 27.0 and 7.0 respectively, it was concluded that a big impact size could be obtained, with $r = 0.836$ value received for it. These findings align with the generally accepted approach to the ADAS-Cog as a symptom measure of cognitive impairment and its potential to discriminate among levels of cognitive dysfunction (5–7,9). The observed differences between the groups also justify the application of general scores in the future.

Overall ADAS-Cog Performance and Domain-Level Findings

The outcomes across all domains of ADAS-Cog were significantly lower in individuals with AD than in the control sample after adjustment for multiple comparisons using the Holm method. Grazing effect varied from moderate to large ($r = 0.396$ – 0.592), indicating that the difference between the groups was not limited to a single cognitive dimension. The biggest domain-level effects were observed in Word Recognition, Ideational Praxis, Word Recall, and Orientation, while Word-Finding Difficulty and Comprehension of Spoken Language showed relatively smaller but still noticeable effects.

There are no contradictions in these results with previous psychometric studies that proved how the instrument reflects different dimensions of cognitive impairment although not all of the components make an equal contribution into the performance evaluation (7–10). Thus, Benge et al. showed that the sensitivity of different ADAS-Cog subscales to cognitive dysfunction varies, while Cano et al. emphasised the need to understand what the score means in light of the specific characteristics of its components (7,9). What is more, Hobart et al. presented limitations of traditional psychometric approaches to the ADAS-Cog and underscored the importance of domain-level knowledge to support results based on the total score (10). Thus, our results confirm validity of using domain measures in addition to total ADAS-Cog scores.

The observed trend should also be analyzed considering the existing limitations of the instrument. Previous studies proved that different domains of ADAS-Cog differ with respect to reliability, sensitivity and responsiveness which means that it should not be viewed as the tool for the assessment of all cognitive aspects (11–14). In particular, ADAS-Cog cannot be referred to the full-fledged executive function test. Instead, it is beneficial because it assesses selected cognitive functions that are typically affected by AD. Thus, our results do not evidence that the cognitive domains of the instrument are assessed in the same way.

Relationship with Clinically Assigned AD Severity

The findings indicated that there were substantial differences in the scores across the three categories of clinical stages of AD, clearly presenting an increase from a median of 20.0 in mild to 29.5 in moderate and lastly 40.0 in severe AD status, which is significant from an analytical-

standpoint ($\eta^2H \approx 0.617$). Moreover, the follow-up pairwise analysis also revealed a consistent pattern (effect size was approximately between 0.616–0.818).

An important methodological strength of the study is that the significance of severity was evaluated by the neurologist without prior access to the ADAS-Cog test scores thus confirming that the significance of the results is due to the sound methodology as it provides the evidence of known-group differentiation of ADAS-Cog performance across independent clinical severity categories (3,4).

However, from the merits of the longitudinal design perspective, it is important to note that the observed differences should not be viewed as evidence of the predictive nature of ADAS-Cog scores in relation to the disease progression trajectory since the obtained data only demonstrate the differences between the groups created for the purposes of the present assessment.

Cultural and Linguistic Applicability of the ADAS-Cog

One of the main focuses of the research work comprised an investigation of an Indian word list that had undergone cultural adaptation. This is particularly significant for India, where cognitive assessments are administered under highly heterogeneous conditions with respect to the language and education of the subjects being tested. In previous studies in India carried out with the help of Indian-adapted versions of the ICMR Neurocognitive Toolbox, Addenbrooke's Cognitive Examination, and MoCA, researchers have also emphasized the prominence of linguistic adaptation and proper cultural administration of cognitive tests when measuring the level of cognitive impairment in Indian subjects (15–18). A larger body of evidence from the literature on culture-free cognitive assessment also indicates that cultural and linguistic specifics affect cognitive test results, suggesting that these factors should be taken into account during data analysis and interpretation (16).

As a part of the analysis, the performance in Word Recall and Word Recognition tasks was examined depending on the word list version used for testing purposes. The results have shown that the participants diagnosed with AD did not exhibit any significant difference between their scores obtained by means of Indian-adapted and original versions of the word list in the task of Word Recall ($p=0.381$), while in the task of Word Recognition the results were significantly different ($p=0.004$). There was no significant difference between the two versions of the word list regarding word recall and word recognition tasks among control group subjects. What is important is that the findings suggest the effect of the word list version is not uniform across cognitive processes and clinical groups. More specifically, the observed difference in Word Recognition indicates that lexical items used in a memory-related task may influence the tested subject's performance and should be considered when interpreting test results in the event of method adaptation.

However, it should be noted that the analysis cannot prove that one of the two-word lists is better than the other for test administration, nor does the non-significant overall comparison imply statistical equivalence. The findings provide additional evidence of the method's performance in the population under study. They align with the general logic of the adaptation work by Lakshminarayanan et al. on Indian ADAS-Cog, which demonstrated that culturally adapted versions of the method were effective in India and were validated in Tamil (20). The current

findings further contribute to this line of inquiry by studying the adapted word list in the broader clinical sample from India and establishing its discriminative ability.

Performance Within the Indian-Adapted Word-List Subgroup

The analysis, limited to participants who used the Indic word list, provided particularly strong evidence of the experiment's cultural dimension. 74 cases of AD and 74 controls were available among those included in this analysis, and AD cases exhibited much higher total ADAS-Cog scores than controls: the median was 27.5 for cases and 8.0 for controls. Word Recall and Word Recognition scores were also notably higher in AD cases than in healthy people. The effect sizes for the total score were large ($r = 0.849$), and for Word Recall the effect size was moderate-large ($r = 0.607$), and in the case of Word Recognition it was also large ($r = 0.624$).

These discoveries prove that the described culturally-suited word list demonstrated good known-groups discrimination in the subgroup in which it was utilized. The findings of the research correspond to the data from the literature sources from India that show that qualified cognitive instruments can be applicable from the diagnostic point of view across diverse language groups in (15–20). However, subgroup findings should not be considered evidence of full cross-cultural equivalence between the Indian version of the tool and the original ADAS-Cog. The procedures of translation/back translation, methods of estimating the equivalence of meaning, measurement invariance and other methods of validation across cultures were not utilized in the study at hand. Thus, the results support the clinical usability of the culturally appropriate word list rather than comprehensive cross-cultural validation.

ROC Performance and Diagnostic Discrimination

The ROC analysis gave further proof how good is the ADAS-Cog score to distinguish AD patients from cognitively healthy controls. In the overall sample, the area under the curve was 0.984 (95% CI, 0.969-0.999), indicating excellent classification performance. Using a cutoff ≥ 16.5 achieves a sensitivity of 91.8% and a specificity of 100.0%, based on the maximum Youden index.

The Indian-word-list subgroup demonstrated similar performance, with an AUC of 0.992. With the cutoff of 16.5, the sensitivity and specificity made 93.2% and 100.0% accordingly while the cutoff of 15.5 resulted in the sensitivity rate of 94.6% and specificity of 98.6%. The maximum value of the Youden index was achieved with both thresholds, that is why the two cutoffs cannot be considered the best.

The findings above align with previous results on the efficacy of ADAS-Cog (6,7,9,21). The systematic review by Park and Han also stressed out the efficiency of the ADAS-Cog in terms of diagnostics but defined that its efficiency varies from population to population (21). Our research has a cultural dimension, given that we might obtain similar results in the Indian-word-list subgroup.

However, it should be stated that the ROC results determine the ability to classify this sample only and should not be regarded as providing a universal measurement of this ability. The sample used for the research included AD patients and cognitively healthy subjects without applying the population variation principle as well as with the cross-sectional outlook of the research. The

Indian-word-list subgroup was smaller than the total sample used for the research. Therefore, the results of the research cannot be extended on other Indian populations. It should be noted that modern tests suggest including various clinical features alongside cognitive tests, rather than relying solely on cognitive tests for this purpose (3,4).

Internal Consistency and Psychometric Interpretation

The observed Cronbach's alpha of 0.853 indicates satisfactory internal consistency of the 11 ADAS-Cog domains used in the current study. This finding is consistent with previous findings already indicating the reliability of the methods used (6,11–14). However, internal consistency should be taken into account, as ADAS-Cog domains assess different cognitive abilities rather than being interchangeable items. Therefore, the fact that the alpha value is satisfactory proves that there is an internal consistency among ADAS domains used in the present study but does not provide any evidence about test-retest reliability, inter-rater reliability or diagnostic validity.

In comparing the current research with previous studies, this distinction is essential. Previous studies examined the longitudinal reliability of ADAS-Cog scores (12,14); however, the current study involved a one-time assessment. This way the current findings may prove the internal consistency and known-groups discrimination of ADAS-Cog domains, but they do not prove the stability of the instrument over time or have an independent cognitive comparator used for convergent or concurrent validity evaluation.

Clinical and Cultural Implications

The results are significant for cognitive assessment in Indian clinical practice, as they reveal excellent discrimination between clinically diagnosed AD and cognitively intact elderly individuals included in the study, and the retention of this discriminative performance when word material is adapted to the culture. This is particularly important, as cognitive assessment in India must account for numerous languages and educational levels. Current Indian evidence obtained from the ICMR Neurocognitive Toolbox and other multilingual instruments emphasizes the even more general rule of adaptation of cognitive assessment to the items used depending on the characteristics of the population involved (15–18).

The findings do not substitute the current Indian ADAS-Cog literature but serve as a continuation of it. Lakshminarayanan et al. provided important data about the cultural adaptation and validation of the Tamil adaptation (20), while the current study focuses on performance in Indian clinical psychology and the comparison of adapted and original word-list, as well as known-groups discrimination and ROC characteristics. Thus, such results confirm the necessity to conduct the further evaluation of culturally appropriate cognitive assessment strategies in India.

Strengths and Limitations

There are various advantages worth mentioning. This research used an unmatched case-control design in which the number of AD cases equalled the number of cognitively normal controls and studied all 11 domains of ADAS-Cog, performed corrections for the multiple tests conducted along domains, provided effect sizes, and evaluated results with respect to the diagnosis severity classification assigned independently from the ADAS-Cog scores. The extra word-list analysis and

the Indian word-list ROC analysis provide additional support for the cultural adaptation aspect of the research. The clinicians used a severity classification that was not based on ADAS-Cog scoring, which means that this method avoided circularity that would have emerged if severity was defined based on ADAS-Cog scores.

The limitations include that the research was performed in one hospital center only, which decreases the degree of generalizability for the community populations and across regions within India. The research was cross-sectional, so there is no opportunity to examine longitudinal progression or causation. The small sample size of the original word-list subgroup limits the interpretation of the observed differences. There was also little evidence that translation/back-translation was used along with the systematic assessment of either semantic or conceptual equivalence. The method of adaptation did not describe using the procedures and steps needed for this research to be valid. It is necessary to express caution regarding the high ROC performance.

CONCLUSION

The results of the study showed that ADAS-Cog scores strongly differentiate between patients with clinically diagnosed AD and cognitively healthy older adults, exhibit significant variations across different clinical severity categories, and show considerable effect sizes in each cognitive domain. Moreover, the adapted Indian word-list analysis provided evidence of preserved differentiation between AD and control subjects in the adapted-word-list subgroup and demonstrated that a specific version of the word-list could influence specific aspects of memory. Overall, the findings confirm the clinical applicability of culturally adapted usage of the ADAS-Cog in the Indian context but call for more multilingual and multicenter studies that will take into account cross-cultural psychometric aspects.

References

1. Choudhary A, Ranjan JK, Asthana HS. Prevalence of dementia in India: A systematic review and meta-analysis. *Indian J Public Health*. 2021;65(2):152–8. doi:10.4103/ijph.IJPH_1042_20 PubMed PMID: 34135184.
2. GBD 2019 Dementia Forecasting Collaborators. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health*. 2022 Feb;7(2):e105–25. doi:10.1016/S2468-2667(21)00249-8 PubMed PMID: 34998485; PubMed Central PMCID: PMC8810394.
3. Jack CR, Andrews JS, Beach TG, Buracchio T, Dunn B, Graf A, et al. Revised criteria for diagnosis and staging of Alzheimer's disease: Alzheimer's Association Workgroup. *Alzheimers Dement*. 2024 Aug;20(8):5143–69. doi:10.1002/alz.13859 PubMed PMID: 38934362; PubMed Central PMCID: PMC11350039.
4. Atri A, Dickerson BC, Clevenger C, Karlawish J, Knopman D, Lin PJ, et al. The Alzheimer's Association clinical practice guideline for the diagnostic evaluation, testing, counseling, and disclosure of suspected Alzheimer's disease and related disorders (DETeCD-ADRD): Validated clinical assessment

instruments. *Alzheimers Dement*. 2025 Jan;21(1):e14335. doi:10.1002/alz.14335 PubMed PMID: 39713939; PubMed Central PMCID: PMC11772712.

5. Rosen WG, Mohs RC, Davis KL. A new rating scale for Alzheimer's disease. *Am J Psychiatry*. 1984 Nov;141(11):1356–64. doi:10.1176/ajp.141.11.1356 PubMed PMID: 6496779.
6. Weyer G, Erzigkeit H, Kanowski S, Ihl R, Hadler D. Alzheimer's Disease Assessment Scale: reliability and validity in a multicenter clinical trial. *Int Psychogeriatr*. 1997 Jun;9(2):123–38. doi:10.1017/s1041610297004298 PubMed PMID: 9309486.
7. Benge JF, Balsis S, Geraci L, Massman PJ, Doody RS. How well do the ADAS-cog and its subscales measure cognitive dysfunction in Alzheimer's disease? *Dement Geriatr Cogn Disord*. 2009;28(1):63–9. doi:10.1159/000230709 PubMed PMID: 19641319.
8. Wouters H, van Gool WA, Schmand B, Lindeboom R. Revising the ADAS-cog for a more accurate assessment of cognitive impairment. *Alzheimer Dis Assoc Disord*. 2008;22(3):236–44. doi:10.1097/WAD.0b013e318174f8b9 PubMed PMID: 18580585.
9. Cano SJ, Posner HB, Moline ML, Hurt SW, Swartz J, Hsu T, et al. The ADAS-cog in Alzheimer's disease clinical trials: psychometric evaluation of the sum and its parts. *J Neurol Neurosurg Psychiatry*. 2010 Dec;81(12):1363–8. doi:10.1136/jnnp.2009.204008 PubMed PMID: 20881017.
10. Hobart J, Cano S, Posner H, Selnes O, Stern Y, Thomas R, et al. Putting the Alzheimer's cognitive test to the test I: traditional psychometric methods. *Alzheimers Dement*. 2013 Feb;9(1 Suppl):S4–9. doi:10.1016/j.jalz.2012.08.005 PubMed PMID: 23253777.
11. Karin A, Hannesdottir K, Jaeger J, Annas P, Segerdahl M, Karlsson P, et al. Psychometric evaluation of ADAS-Cog and NTB for measuring drug response. *Acta Neurol Scand*. 2014 Feb;129(2):114–22. doi:10.1111/ane.12153 PubMed PMID: 23763450.
12. Khan A, Yavorsky C, DiClemente G, Opler M, Liechti S, Rothman B, et al. Reliability of the Alzheimer's disease assessment scale (ADAS-Cog) in longitudinal studies. *Curr Alzheimer Res*. 2013 Nov;10(9):952–63. doi:10.2174/15672050113106660160 PubMed PMID: 24117118.
13. Cogo-Moreira H, Krance SH, Wu CY, Lanctôt KL, Herrmann N, Black SE, et al. State, trait, and accumulated features of the Alzheimer's Disease Assessment Scale Cognitive Subscale (ADAS-Cog) in mild Alzheimer's disease. *Alzheimers Dement (N Y)*. 2023;9(1):e12376. doi:10.1002/trc2.12376 PubMed PMID: 36994227; PubMed Central PMCID: PMC10040491.
14. Chiu EC, Wang YC, Huang SL, Hsueh IP, Chiang HY, Hsieh CL. Test-retest reliabilities and minimal detectable changes of 5 versions of the Alzheimer's Disease Assessment Scale-Cognitive Subscale in people with dementia. *Disabil Rehabil*. 2023 Apr;45(8):1398–404. doi:10.1080/09638288.2022.2060334 PubMed PMID: 35403536.
15. Menon RN, Varghese F, Paplikar A, Mekala S, Alladi S, Sharma M, et al. Validation of Indian Council of Medical Research Neurocognitive Tool Box in Diagnosis of Mild Cognitive Impairment in India: Lessons from a Harmonization Process in a Linguistically Diverse Society. *Dement Geriatr Cogn Disord*. 2020;49(4):355–64. doi:10.1159/000512393 PubMed PMID: 33412549.

16. Verma M, Tripathi M, Nehra A, Paplikar A, Varghese F, Alladi S, et al. Validation of ICMR Neurocognitive Toolbox for Dementia in the Linguistically Diverse Context of India. *Front Neurol.* 2021;12:661269. doi:10.3389/fneur.2021.661269 PubMed PMID: 34733226; PubMed Central PMCID: PMC8558406.
17. Mekala S, Paplikar A, Mioshi E, Kaul S, Divyaraj G, Coughlan G, et al. Dementia Diagnosis in Seven Languages: The Addenbrooke's Cognitive Examination-III in India. *Arch Clin Neuropsychol.* 2020 Jul 24;35(5):528–38. doi:10.1093/arclin/acia013 PubMed PMID: 32188967.
18. Kaul S, Paplikar A, Varghese F, Alladi S, Sharma M, Dhaliwal RS, et al. MoCA in five Indian languages: A brief screening tool to diagnose dementia and MCI in a linguistically diverse setting. *Int J Geriatr Psychiatry.* 2022 Oct;37(10). doi:10.1002/gps.5808 PubMed PMID: 36069187.
19. Chithiramohan T, Santhosh S, Threlfall G, Hull L, Mukaetova-Ladinska EB, Subramaniam H, et al. Culture-Fair Cognitive Screening Tools for Assessment of Cognitive Impairment: A Systematic Review. *J Alzheimers Dis Rep.* 2024;8(1):289–306. doi:10.3233/ADR-230194 PubMed PMID: 38405352; PubMed Central PMCID: PMC10894602.
20. Lakshminarayanan M, Vaitheswaran S, Srinivasan N, Nagarajan G, Ganesh A, Shaji KS, et al. Cultural adaptation of Alzheimer's disease assessment scale-cognitive subscale for use in India and validation of the Tamil version for South Indian population. *Aging Ment Health.* 2022 Feb;26(2):423–30. doi:10.1080/13607863.2021.1875192 PubMed PMID: 33491464; PubMed Central PMCID: PMC7613307.
21. Park SH, Han KS. Is the Alzheimer's Disease Assessment Scale-Cognitive Subscale Useful in Screening for Mild Cognitive Impairment and Alzheimer's Disease? A Systematic Review. *Curr Alzheimer Res.* 2022;19(3):202–11. doi:10.2174/1567205019666220404104854 PubMed PMID: 35379127.