

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

Abstract

Background

The Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-Cog) is widely used to characterize cognitive impairment in Alzheimer's disease (AD). However, linguistic and cultural factors may influence cognitive-test performance in multilingual populations. This study evaluated total and domain-specific ADAS-Cog performance across clinically classified levels of cognitive impairment in an urban Indian clinical population.

Methods

This single-center, hospital-based, cross-sectional observational study included 120 participants aged ≥ 60 years with clinically diagnosed mild cognitive impairment (MCI), mild AD, moderate AD, or severe AD. Participants were recruited from the neurology clinic of Marengo Asia Hospital, Gurugram, India. Clinical severity was assigned by the treating neurologist independently of the ADAS-Cog outcome measure. The ADAS-Cog was administered using standardized procedures in the participant's preferred assessment language, with an Indian culturally adapted word list used where appropriate. Total and domain-specific scores were compared using Welch's analysis of variance (ANOVA), with Games–Howell post-hoc comparisons. Holm adjustment was applied to the eleven domain-level comparisons. Associations with age and education were examined using Spearman's rank correlation and adjusted analyses that accounted for clinical severity, sex, assessment language, and word-list version.

Results

The mean ADAS-Cog total score increased progressively across clinical severity groups: 14.60 ± 1.46 in MCI, 22.11 ± 2.39 in mild AD, 33.80 ± 3.56 in moderate AD, and 52.25 ± 3.93 in severe AD. Welch ANOVA demonstrated a significant difference across groups ($F(3, 51.30) = 748.50$, $p < 0.001$). Games–Howell comparisons demonstrated significant differences between every pair of clinical severity groups (all $p < 0.001$), with mean differences ranging from 7.51 to 37.65 points. All eleven domain-level comparisons remained statistically significant after Holm correction. The unadjusted correlations between total ADAS-Cog score and age ($\rho = 0.738$, $p < 0.001$) and education ($\rho = -0.708$, $p < 0.001$) were strong; however, after adjustment for clinical severity and other covariates, the association with education was no longer statistically significant.

Conclusion

The findings provide preliminary evidence that culturally adapted administration of the ADAS-Cog can distinguish between clinically classified levels of cognitive impairment in this urban Indian sample. The results support further evaluation of culturally and linguistically appropriate administration approaches, but do not constitute comprehensive validation of the modified instrument. Multicenter studies incorporating diagnostic accuracy, convergent validity, reliability, and longitudinal assessment are required before broader generalization.

Keywords: Alzheimer's disease; mild cognitive impairment; Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-Cog); cognitive assessment; cognitive reserve; cultural adaptation.

Introduction

Alzheimer's Disease (AD) is a leading cause of dementia and a serious global public health concern. The continued prevalence increase for AD due to the growth of the older population contributes greatly to disability, dependence, and Healthcare burden on the older population.^{1,2} The continued clinical course of AD is marked by gradually worsening memory, language, executive function, orientation, and daily living skills, leading to progressively greater functional impairment and an inability to live independently.^{3–5} Mild Cognitive Impairment (MCI) is now recognized as being between normal cognitive aging and dementia and has a greater likelihood of progressing to AD.^{6,7} Therefore, the prompt identification and precise characterization of MCI are critical for the timely clinical intervention of patients with mild cognitive impairment, the ongoing monitoring of disease progression, and the assessment of the results of therapies.^{3,6} The cognitive assessment tools that can be relied upon serve as essential products for diagnosing and following up on all dementia patients who present with mild to moderate cognitive impairment and mild, moderate, and severe dementia related to AD. Among the many cognitive assessment tools available, the Alzheimer's Disease Assessment Scale-Cognitive Subscale (ADAS-Cog) remains the most widely used cognitive outcome measure for clinical and research purposes.^{8,9} The original developers, Rosen et al., had specific assessments in mind, including multiple areas of cognition affected by AD, such as memory, language, spatial orientation, praxis skills, and comprehension.⁸ Since then, additional refinements and changes to the ADAS-Cog have expanded its potential and flexibility for use with individuals at all levels of cognitive decline.^{9,10}

The original Alzheimer's Disease Assessment Scale (ADAS) was developed by Rosen et al. and published in 1984. Subsequent work expanded the cognitive assessment framework and established the ADAS-Cog as a widely used measure of cognitive impairment in Alzheimer's disease clinical research.^{8,9} The ADAS-Cog has been used for decades as an endpoint in multiple observational studies and clinical trials involving patients with Alzheimer's disease, and is also used in the U.S. Food and Drug Administration's (FDA) new drug application process for many

medicines for the treatment of AD.^{11,12} The psychometric validation of the ADAS-Cog has confirmed its validity in assessing cognitive deficits and tracking disease progression.¹¹⁻¹³ However, there are concerns about its sensitivity at the early stages of cognitive impairment, the potential for ceiling effects and floor effects, and variability in how the measure is administered and scored.^{11,12,14}

In addition to underlying neuropathologies, the cognitive performance of older adults is influenced by typical demographic characteristics. As in the general population, increasing age represents the greatest risk factor for developing AD and cognitive decline.^{1,2} Conversely, the educational level achieved correlates with higher cognitive reserve and possibly delays the occurrence of dementia in cases where AD pathology is present.¹⁵ Some systematic reviews and meta-analyses have shown a significant and inverse relationship between educational attainment and dementia risk and thus support the notion that educational experiences potentially offer some resilience to cognitive impairment.^{16,17}

Another challenge in cognitive assessment is the effect of cultural and linguistic diversity on cognitive function and the assessment process. For example, many neuropsychological test instruments were developed using Western populations, so they are likely influenced by linguistic and cultural differences, as well as by the educational backgrounds and testing conditions of the people taking the tests.^{18,19} The importance of adapting the administration and interpretation of neuropsychological assessments for cross-cultural use has been highlighted in numerous cross-cultural neuropsychology studies.²⁰⁻²² In India, the need for cross-cultural adaptation of the assessment process is even more critical due to the significant linguistic diversity in the Indian population, among other factors that may affect how an individual scores on cognitive assessment instruments. Many studies of older adults conducted in Indian populations have documented the need to administer cognitive assessments using culturally appropriate methods.²³⁻²⁵ Even though many people use the ADAS-Cog internationally, there is insufficient evidence to demonstrate its effectiveness and relevance in the Culturally Adapted Indian Clinical Setting. In addition, only a very limited number of studies have used data on Domain-wise ADAS-Cog performance for different stages of cognitive impairment in multilingual Indian populations. Therefore, this research will evaluate the ADAS-Cog performance of urban Indian patients with MCI and AD. The objectives of this study include

comparing total and domain-wise ADAS-Cog scores across clinical severity categories and exploring the relationships among cognitive performance, age, and level of education within a culturally adapted assessment perspective.

Methods

Study Design and Setting

This was a single-center, hospital-based, cross-sectional observational study conducted in the Department of Neurology in a tertiary care centre in central India. Each participant underwent one assessment, and no experimental intervention was administered. The study was conducted in accordance with the approved study protocol. Ethical approval was obtained from the Institutional Ethics Committee on **29 January 2026**, before initiation of participant recruitment (LMH/IEC/38/2026).

Participants

Participants were recruited consecutively from the outpatient neurology clinic. Eligible participants were aged ≥ 60 years and had a clinical diagnosis of MCI or AD documented by the treating neurologist. Clinical diagnoses were made according to the National Institute on Aging–Alzheimer's Association (NIA-AA) diagnostic framework. Participants were categorized clinically as MCI, mild AD, moderate AD, or severe AD by the treating neurologist. Importantly, clinical severity classification was based on the established clinical diagnosis and was not defined by the ADAS-Cog score; ADAS-Cog was subsequently administered as the study outcome measure.^{3,6} Participants were excluded if they had severe visual, auditory, speech, or motor impairment that precluded valid cognitive assessment; acute delirium; major psychiatric illness or unstable medical illness likely to interfere with testing; non-AD dementia outside the study framework; severe behavioural disturbance preventing completion of the assessment; or incomplete clinical or ADAS-Cog documentation.

Sample Size Calculation

The sample size was prespecified in the study protocol based on the primary correlation objective: the association between the total ADAS-Cog score and relevant demographic/clinical variables. Assuming an anticipated correlation coefficient of $r = 0.30$, a two-sided α level of

0.05, and 80% power, the Fisher z-transformation approach yielded a minimum sample size of approximately 85 participants. The target sample size was subsequently increased to 120 participants to account for potential incomplete assessments, ensure subgroup representation across clinical severity categories, and improve the precision of estimates. A total of 120 participants were ultimately included in the analysis.

Study Instrument

The ADAS-Cog India data collection form was used to collect the data in this study. The ADAS-Cog India data collection form underwent content validation by a panel of five subject experts, demonstrating excellent content validity (Content Validity Index [CVI] = 1.00). The data collection form included items on demographic details, clinical background, language used during evaluation, selection of the word list for measurement, documentation of informed consent, scoring of the individual cognitive domains, and calculation of the total ADAS-Cog score. The ADAS-Cog cognitive assessment tool measured 11 cognitive domains: Word Recall, Naming of Objects and Fingers, Following Commands, Constructional Praxis, Ideational Praxis, Orientation, Recognition of Words, Remembering the Instructions of a Test, Speaking Ability, Difficulty Finding Words, and Understanding Spoken Language. An individual's overall score on the ADAS-Cog scale ranged from 0 to 70, with higher scores indicating greater cognitive impairment.^{8,9} The 11-domain ADAS-Cog demonstrated good internal consistency in the present study, with a Cronbach's alpha coefficient of 0.853.

Cultural and Linguistic Adaptation

The ADAS-Cog was administered in the participant's preferred assessment language using standardized administration and scoring procedures. To improve cultural familiarity for the Word Recall and Word Recognition components, an Indian-culturally adapted ten-word list was available and used where appropriate. The adapted list comprised Tulsi, Ganga, Dupatta, Tabla, Rickshaw, Chawl, Marigold, Dhaba, Minaret, and Charpoy. The original ADAS-Cog word list remained available when clinically indicated. The assessment framework and data collection form underwent expert content review by five subject experts, yielding a content validity index of 1.00. This expert review was considered evidence of content validity and was not interpreted as comprehensive cross-cultural validation.²⁰

Data Collection Procedure

Once participants were confirmed as eligible and had provided written informed consent, clinicians recorded each participant's demographic and clinical information in accordance with safety guidelines. Subsequently, the ADAS-Cog Assessment was administered to each participant individually in accordance with the standard protocol. To measure the Word Recall domain, each participant completed three separate recall trials, and the domain score was computed as the average of the number of words that had not been recalled in any of the three trials. The scores associated with each of the remaining domains of the ADAS-Cog Assessment were assigned based on the standard ADAS-Cog Administration guidelines. All domain scores were then summed to create the overall ADAS-Cog score.

Outcome Measures

The ADAS-Cog total score was the main outcome variable. Additionally, other outcomes included ADAS-Cog scores for each domain separately; comparisons between total and domain-specific ADAS-Cog scores across clinical severity categories; and associations between the total ADAS-Cog score and demographic characteristics, such as age and years of education.

Statistical Analysis

Continuous variables were summarized using means and standard deviations, and categorical variables using frequencies and percentages. Distributional characteristics were assessed using graphical methods and the Shapiro–Wilk test. Because the clinical severity groups were unequal in size and heterogeneity of variance was present, comparisons of total ADAS-Cog scores were performed using Welch's one-way ANOVA, followed by Games–Howell pairwise comparisons. The eleven domain-level comparisons were similarly evaluated using Welch's ANOVA, and the resulting p-values were adjusted using the Holm procedure to control the family-wise error rate. Effect sizes and 95% confidence intervals were reported where appropriate.

Spearman's rank correlation was initially used to evaluate associations between the total ADAS-Cog score, age, and years of formal education. Because demographic characteristics differed across clinical severity groups, additional adjusted analyses were performed using multivariable linear regression, incorporating clinical severity, age, education, sex, assessment language, and word-list version. Partial correlations were also examined where appropriate. The

influence of assessment language and word-list version on total ADAS-Cog score was evaluated separately. All tests were two-sided, with $p < 0.05$ considered statistically significant except where multiplicity adjustment was specified.

Ethical Considerations

This study was conducted in compliance with the ethical standards of the Declaration of Helsinki. Before participant recruitment, ethical approval for this study was obtained from the Institutional Ethics Committee. Participants or their authorized representatives provided written consent after receiving sufficient information about the study and what would be required of them. Participants' confidentiality was maintained, and all analyses were conducted using anonymous data.

Results

Participant Characteristics

A total of 120 participants were included in the analysis, with no missing ADAS-Cog assessments. According to the clinical severity classification, 35 (29.2%) participants had mild cognitive impairment (MCI), 35 (29.2%) had mild Alzheimer's disease (AD), 30 (25.0%) had moderate AD, and 20 (16.7%) had severe AD. The overall mean age was 75.70 ± 3.98 years, and the mean duration of formal education was 15.25 ± 2.07 years. The mean symptom duration was 34.67 ± 19.03 months, and the mean duration since diagnosis was 16.31 ± 12.84 months. There were 60 male (50.0%) and 60 female (50.0%) participants. A family history of dementia was reported by 26 (21.7%) participants. Hindi was the assessment language for 44 (36.7%) participants and English for 40 (33.3%), while the remaining participants were assessed in Tamil, Marathi, Telugu, Punjabi, or Bengali. The culturally adapted Indian word list was used in 98 (81.7%) participants, while the original ADAS-Cog word list was used in 22 (18.3%) participants.

Demographic characteristics differed across the clinical severity groups. Mean age increased progressively from 72.06 ± 2.27 years in the MCI group to 80.35 ± 2.92 years in the severe AD group. Similarly, mean years of formal education decreased from 17.11 ± 1.25 years in the MCI

group to 13.25 ± 1.52 years in the severe AD group. The distributions of age and education differed significantly across the four severity groups (Kruskal–Wallis $p < 0.001$ for both). Sex distribution did not differ significantly across groups (χ^2 test, $p = 0.135$). The demographic characteristics according to clinical severity are presented in **Table 1**.

Table 1. Demographic and Clinical Characteristics of the Study Population

Variable	MCI (n=35)	Mild AD (n=35)	Moderate AD (n=30)	Severe AD (n=20)	p-value
Age, years, mean $\pm$ SD	72.06 $\pm$ 2.27	75.31 $\pm$ 3.16	77.30 $\pm$ 2.83	80.35 $\pm$ 2.92	<0.001
Formal education, years, mean $\pm$ SD	17.11 $\pm$ 1.25	15.51 $\pm$ 1.27	14.10 $\pm$ 1.99	13.25 $\pm$ 1.52	<0.001
Female, n (%)	21 (60.0)	17 (48.6)	10 (33.3)	12 (60.0)	0.135
Male, n (%)	14 (40.0)	18 (51.4)	20 (66.7)	8 (40.0)	—

Abbreviations: AD, Alzheimer's disease; MCI, mild cognitive impairment; SD, standard deviation.

Internal Consistency of the ADAS-Cog

The internal consistency of the 11 ADAS-Cog domains was assessed using Cronbach's alpha. The instrument demonstrated good internal consistency, with a Cronbach's alpha coefficient of **0.853** across the 11 domains (Table 2).

Table 2. Internal Consistency of the ADAS-Cog

Measure	Value
Number of cognitive domains	11
Cronbach's alpha	0.853

ADAS-Cog Total Scores Across Clinical Severity Categories

Mean ADAS-Cog total scores increased progressively across the clinically classified severity groups, from **14.60 ± 1.46** in participants with MCI to **52.25 ± 3.93** in those with severe AD (Table 3). The corresponding 95% confidence intervals showed clear separation between the severity groups.

Because the groups were unequal in size and heterogeneity of variance was present, Welch's one-way ANOVA was used. The analysis demonstrated a statistically significant difference in total ADAS-Cog scores across the four clinical severity groups (Welch $F(3, 51.30) = 748.50$, $p < 0.001$). The overall effect was very large ($\eta^2 = 0.956$). Games–Howell post hoc comparisons demonstrated statistically significant differences across all six pairs of severity groups (all $p < 0.001$). Thus, total ADAS-Cog scores were progressively higher across the clinically classified categories from MCI through severe AD. The distribution of total ADAS-Cog scores across the four severity categories is illustrated in **Figure 1**.

Table 3. ADAS-Cog Total Scores According to Clinical Severity

Clinical Severity	n	Mean ± SD	95% Confidence Interval
Mild Cognitive Impairment	35	14.60 ± 1.46	14.10–15.10
Mild Alzheimer's disease	35	22.11 ± 2.39	21.30–22.93
Moderate Alzheimer's disease	30	33.80 ± 3.56	32.47–35.13
Severe Alzheimer's disease	20	52.25 ± 3.93	50.41–54.09

Welch's ANOVA: $F(3, 51.30) = 748.50$; $p < 0.001$; $\eta^2 = 0.956$.

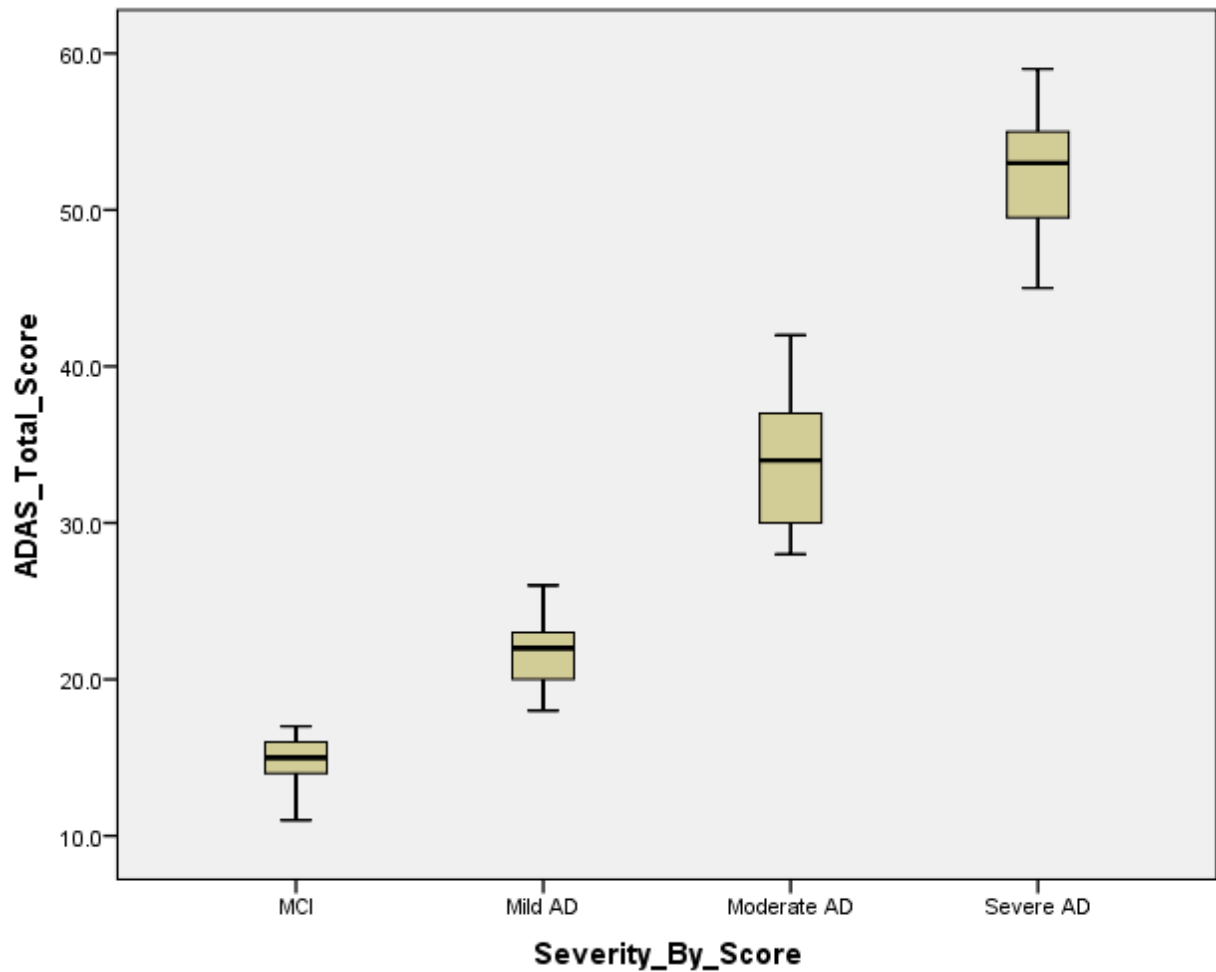


Figure 1. Distribution of ADAS-Cog Total Scores Across Clinical Severity Categories of Cognitive Impairment and Alzheimer's Disease

Figure legend: Box-and-whisker plot demonstrating the progressive increase in ADAS-Cog total scores across the clinically classified severity categories from MCI to severe AD.

Domain-wise ADAS-Cog Performance

Domain-wise analysis demonstrated statistically significant differences across all 11 ADAS-Cog domains according to clinical severity after adjustment for multiple comparisons using the Holm procedure (all adjusted $p < 0.001$ except Comprehension of Spoken Language, adjusted $p = 0.002$; Table 4).

The magnitude of the Welch F statistics varied across domains. The largest difference was observed for Ideational Praxis (Welch $F(3, 61.67) = 89.08$, adjusted $p < 0.001$), followed by Following Commands (Welch $F(3, 57.44) = 66.81$, adjusted $p < 0.001$) and Orientation (Welch $F(3, 62.83) = 59.43$, adjusted $p < 0.001$). Significant differences were also observed for Constructional Praxis, Naming, Word Recall, Word Recognition, Remembering Test Instructions, Spoken Language, Word-Finding Difficulty, and Comprehension of Spoken Language.

Across the individual domains, scores generally increased with greater clinical severity, indicating greater impairment among participants classified with more advanced disease. The findings demonstrated differences across memory, language, orientation, praxis, and other cognitive domains rather than being confined to a single component of the ADAS-Cog.

Table 4. Domain-wise ADAS-Cog Scores According to Clinical Severity

ADAS-Cog domain	MCI (n=35)	Mild AD (n=35)	Moderate AD (n=30)	Severe AD (n=20)	Welch F	df ₂	Holm-adjusted p
Word Recall	3.66 ± 1.45	5.03 ± 2.01	5.60 ± 1.55	8.25 ± 2.10	26.803	56.496	<0.001
Naming	0.54 ± 1.25	0.83 ± 1.15	2.57 ± 1.61	3.45 ± 1.19	32.382	58.234	<0.001
Following Commands	0.26 ± 0.89	1.14 ± 1.46	2.60 ± 1.50	4.05 ± 1.05	66.807	57.438	<0.001
Constructional Praxis	0.31 ± 0.90	1.20 ± 1.11	2.17 ± 1.09	3.95 ± 1.15	54.002	57.141	<0.001
Ideational Praxis	0.40 ± 1.09	1.14 ± 1.38	2.57 ± 1.33	4.50 ± 0.83	89.082	61.669	<0.001
Orientation	2.71 ± 2.14	3.29 ± 1.64	4.47 ± 1.36	7.30 ± 1.03	59.432	62.830	<0.001
Word Recognition	2.66 ± 1.83	3.54 ± 1.69	5.00 ± 1.80	7.75 ± 2.69	22.613	55.651	<0.001
Remembering Test Instructions	0.94 ± 1.61	1.17 ± 1.42	2.27 ± 1.44	3.60 ± 1.27	19.291	59.897	<0.001
Spoken Language	0.51 ± 0.70	1.66 ± 1.41	2.13 ± 1.31	3.10 ± 1.52	27.044	52.572	<0.001
Word-Finding Difficulty	1.57 ± 1.12	1.69 ± 1.28	2.77 ± 1.48	3.35 ± 1.63	9.431	55.920	<0.001
Comprehension of Spoken Language	1.03 ± 1.51	1.43 ± 1.48	1.67 ± 1.24	2.95 ± 1.79	5.507	57.031	0.002

Abbreviations: AD, Alzheimer's disease; MCI, mild cognitive impairment; df₂, denominator degrees of freedom

Association of ADAS-Cog Total Score with Age and Education

Unadjusted Spearman rank correlation analysis demonstrated a strong positive association between age and total ADAS-Cog score ($\rho = 0.738$, $p < 0.001$). Conversely, years of formal education demonstrated a strong negative association with total ADAS-Cog score ($\rho = -0.708$, $p < 0.001$) (Table 5).

Because both age and education differed significantly across the clinical severity groups, adjusted analyses were performed to account for potential confounding. After adjustment for clinical severity, sex, assessment language, and word-list version, the association between age and total ADAS-Cog score remained modest but statistically significant (partial $r = 0.204$, $p = 0.033$). In contrast, the association between years of formal education and total ADAS-Cog score was no longer statistically significant (partial $r = -0.127$, $p = 0.188$).

Table 5. Correlation Between ADAS-Cog Total Score and Demographic Variables

Variable	Unadjusted Spearman ρ	Unadjusted p-value	Adjusted partial r^*	Adjusted p-value
Age (years)	0.738	<0.001	0.204	0.033
Years of formal education	-0.708	<0.001	-0.127	0.188

*Adjusted for clinical severity, sex, assessment language, and word-list version.

Influence of Assessment Language and Word-List Version

Assessment language was examined because participants underwent cognitive testing in different preferred languages. Hindi was used by 44 participants, English by 40, Tamil by 11, Marathi by 9, Telugu by 8, Punjabi by 6, and Bengali by 2. Total ADAS-Cog scores did not differ significantly according to assessment language (Kruskal–Wallis $H = 3.167$, $p = 0.788$).

The culturally adapted Indian word list was used in 98 participants, while the original ADAS-Cog word list was used in 22 participants. Total ADAS-Cog scores did not differ significantly between participants assessed with the Indian-adapted word list and those assessed with the original word list (Mann–Whitney $U = 1356.5$, $p = 0.059$). Given the unequal group

sizes, particularly for individual assessment languages and the original word-list group, these comparisons were interpreted cautiously.

Table 6. Total ADAS-Cog Scores According to Assessment Language and Word-List Version

Variable	n	Mean $\pm$ SD	Statistical test	p-value
Assessment language			Kruskal–Wallis H = 3.167	0.788
English	40	25.92 $\pm$ 11.71		
Hindi	44	27.93 $\pm$ 13.58		
Tamil	11	32.18 $\pm$ 14.33		
Marathi	9	26.33 $\pm$ 14.46		
Telugu	8	27.38 $\pm$ 15.26		
Punjabi	6	33.17 $\pm$ 15.24		
Bengali	2	34.50 $\pm$ 27.58		
Word-list version			Mann–Whitney U = 1356.5	0.059
Indian adapted word list	98	29.02 $\pm$ 13.75		
Original ADAS-Cog word list	22	22.73 $\pm$ 10.11		

Abbreviation: SD, standard deviation.

Multivariable Analysis of Factors Associated with ADAS-Cog Total Score

A multivariable linear regression model incorporating clinical severity, age, years of formal education, sex, assessment language, and word-list version was statistically significant ($R^2 = 0.966$, adjusted $R^2 = 0.961$, $p < 0.001$). Clinical severity remained the principal factor associated

with total ADAS-Cog score after adjustment for the demographic and assessment-related variables.

After accounting for clinical severity and the other covariates, age retained a modest association with total ADAS-Cog score, whereas years of formal education was no longer statistically significant. Neither the assessment language nor the word-list version demonstrated a statistically significant independent association with the total ADAS-Cog score. Sex likewise did not demonstrate a statistically significant independent association in the adjusted model.

Discussion

The present study evaluated the performance of the Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-Cog) among urban Indian patients with mild cognitive impairment (MCI) and Alzheimer's disease (AD) across clinically defined severity categories. The principal finding was a marked and progressive increase in total ADAS-Cog scores from MCI through mild, moderate, and severe AD. Mean scores increased from 14.60 in MCI to 22.11 in mild AD, 33.80 in moderate AD, and 52.25 in severe AD. Welch's ANOVA demonstrated a significant difference across the four groups, and Games–Howell post-hoc comparisons showed significant differences between every pair of severity categories. These findings indicate a strong association between ADAS-Cog performance and clinically defined cognitive severity in this cohort.

The observed increase in ADAS-Cog scores across severity categories is consistent with the original purpose of the instrument, which was developed to quantify cognitive dysfunction in Alzheimer's disease.⁸ Subsequent clinical and research studies have established the widespread use of ADAS-Cog for evaluating cognitive impairment in AD and for measuring differences in cognitive performance across disease severity.^{9,11,12} Previous work has also demonstrated that ADAS-Cog-based measures can distinguish among levels of cognitive impairment.¹³ However, because the present study was cross-sectional, the observed differences should be interpreted as between-group differences across clinically defined severity categories rather than evidence of longitudinal disease progression.

Domain-level analysis demonstrated significant differences across all 11 ADAS-Cog domains after Holm correction for multiple comparisons. Memory-related domains showed increasing impairment with greater clinical severity, consistent with the prominent role of episodic memory impairment in the clinical presentation of AD.^{3,5,6} In addition, significant differences were observed in orientation, praxis, language, word finding, and comprehension, indicating that impairment was not restricted to memory-related performance. Previous literature has similarly described the progressive involvement of orientation and language-related functions as cognitive impairment advances.^{11,12}

The largest between-group differences were observed in ideational praxis, constructional praxis, and following commands. These findings suggest a substantial deterioration in the ability to perform structured cognitive and praxis-related tasks with increasing clinical severity. Previous studies using ADAS-Cog have also reported differences across individual cognitive domains as disease severity increases.^{10,11,13} Nevertheless, the findings should not be interpreted as evidence of impairment in a comprehensive “executive function,” because the standard ADAS-Cog is not a dedicated executive-function battery. Rather, the present results indicate progressive impairment across the specific cognitive and praxis-related functions assessed by the instrument.

Age demonstrated a strong positive crude association with total ADAS-Cog score. Older participants had higher scores, indicating greater cognitive impairment. Age is an established non-modifiable risk factor for dementia, and increasing age is associated with a greater burden of age-related and neurodegenerative pathology.^{1,2} However, age also differed significantly between the clinical severity groups in the present study. After adjustment for clinical severity, sex, assessment language, and word-list version, the association between age and ADAS-Cog score was substantially attenuated, although it remained statistically significant. Thus, the crude association between age and ADAS-Cog performance appears to be partly related to differences in clinical severity, while age may also contribute modestly to score variability.

Years of formal education showed a strong negative crude correlation with ADAS-Cog scores, with lower educational attainment associated with higher cognitive scores. Education also differed significantly across severity groups, and the association was substantially attenuated after adjustment for severity and other covariates. These findings emphasize the importance of considering educational background when interpreting cognitive test performance in

heterogeneous populations.¹⁵ Previous studies and systematic reviews have reported associations between educational attainment, cognitive performance, and cognitive reserve.^{16,17} However, the present cross-sectional findings do not establish that education has a protective or causal effect on AD-related cognitive decline. Rather, they support the need to account for educational differences when interpreting cognitive assessment results.

A key feature of the present study was the incorporation of cultural and linguistic considerations into the administration of ADAS-Cog. Western-developed neuropsychological instruments may be influenced by cultural familiarity, language proficiency, and educational background, potentially introducing measurement bias when applied across culturally diverse populations.^{18,19} Cross-cultural neuropsychological literature emphasizes the importance of adapting assessment procedures while preserving the conceptual meaning of the original instrument.^{20–22} In the present study, participants were assessed in their preferred language, and a culturally relevant Indian word list was used in most assessments. This approach enhances the contextual relevance of the assessment for a multilingual Indian clinical population and aligns with the broader need for culturally sensitive cognitive assessment.^{23,24}

The language analysis did not demonstrate a statistically significant difference in total ADAS-Cog scores across assessment-language groups. However, the language groups were unequal, with very small numbers in some categories. Therefore, the absence of a statistically significant difference should not be interpreted as evidence that the different language administrations are psychometrically equivalent. Similarly, the comparison between the culturally adapted and original word lists did not show a statistically significant difference in total ADAS-Cog score, but the groups were markedly unequal in size. These findings should therefore be considered exploratory rather than evidence of equivalence between word-list versions.

The relevance of these findings is particularly important in the Indian context, where linguistic diversity and differences in educational attainment may influence performance on standardized cognitive assessments.^{23–25} The present study provides preliminary clinical evidence that culturally adapted administration can be used to distinguish clinically defined levels of cognitive impairment in an urban Indian population. However, this should not be interpreted as comprehensive cross-cultural validation. The documented adaptation included expert content

review but did not establish formal translation/back-translation, systematic assessment of semantic or conceptual equivalence, or comprehensive psychometric validation. Thus, the findings primarily support preliminary applicability and content relevance rather than definitive cross-cultural equivalence.

The multivariable analysis further strengthened the interpretation of the findings. After adjustment for age, education, sex, assessment language, and word-list version, clinical severity remained the dominant factor associated with total ADAS-Cog performance. The attenuation of the crude education association following adjustment also indicates that demographic differences between severity groups contributed to the unadjusted relationship. These results support the interpretation that the large differences in ADAS-Cog scores were principally associated with clinical severity, while demographic and administration-related factors should nevertheless be considered when interpreting individual scores.

The internal consistency of the 11-domain assessment was good, with Cronbach's $\alpha = 0.853$. This supports satisfactory internal consistency in the present sample but should not be interpreted as evidence of comprehensive reliability or validity. Cronbach's alpha does not establish test-retest reliability, inter-rater reliability, criterion validity, diagnostic accuracy, or responsiveness to longitudinal change. Accordingly, the psychometric findings from this study should be regarded as preliminary.

Strengths and Limitations

The present study has several strengths, including the inclusion of participants across a broad spectrum of clinically defined cognitive severity, from MCI to severe AD, and the assessment of both total ADAS-Cog scores and all 11 individual domains. The use of Welch's ANOVA, Games-Howell post-hoc testing, and Holm correction strengthened the statistical analysis in the presence of unequal variances and multiple comparisons. The incorporation of culturally relevant word-list material and multilingual administration also enhanced the clinical relevance of the assessment framework for the Indian setting. In addition, complete ADAS-Cog data were available for all participants. However, the single-center, cross-sectional design limits generalizability and precludes conclusions regarding longitudinal cognitive progression or causality. The language and word-list groups were unequal, limiting conclusions regarding linguistic and word-list equivalence. Although cultural adaptation and expert content review

were undertaken, formal translation/back-translation, systematic testing of semantic or conceptual equivalence, and comprehensive psychometric validation were not documented; therefore, the findings should be considered preliminary evidence of applicability rather than full cross-cultural validation. Age and education also differed across severity groups, and although these factors were accounted for in the adjusted analyses, residual confounding cannot be excluded. Finally, the study assessed internal consistency but did not evaluate other psychometric properties such as test–retest reliability, inter-rater reliability, criterion validity, or responsiveness to longitudinal change.

Future Research

Future studies should include multicenter and longitudinal designs across different geographic regions of India, with adequate representation of major language groups, educational levels, and urban and rural populations. Formal translation and back-translation, assessment of semantic and conceptual equivalence, and prospective psychometric validation should be incorporated into future culturally adapted versions. Larger studies should also evaluate the equivalence of individual language versions and word-list variants using standardized allocation procedures. Longitudinal studies assessing responsiveness to cognitive change, together with evaluations of test–retest reliability, inter-rater reliability, criterion validity, and relationships with functional outcomes and biomarkers, would provide stronger evidence of the clinical utility of the culturally adapted ADAS-Cog.

Conclusion

The present study provides preliminary evidence that the culturally adapted administration of the ADAS-Cog can distinguish among clinically classified levels of cognitive impairment in older adults attending an urban Indian neurology service. Total ADAS-Cog scores and all eleven domain scores differed significantly across MCI, mild AD, moderate AD, and severe AD groups, with substantial between-group effects. Unadjusted associations with age and education were also observed, although these relationships were attenuated after accounting for clinical severity and other covariates. The findings support further investigation into culturally and linguistically appropriate approaches to administering cognitive assessments in India. However, the study

should not be interpreted as a comprehensive validation of the culturally adapted ADAS-Cog. Multicenter studies involving broader linguistic and educational populations, healthy controls, diagnostic accuracy analyses, convergent validity, test–retest and inter-rater reliability, and longitudinal follow-up are warranted.

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