Best Evidence Summaries of Topics in Mental Healthcare

BEST *in* MH *clinical question-answering service*

Question

In adults with cognitive impairment or memory problems how effective is the MoCA (Montreal Cognitive Assessment) compared to the MMSE (Mini Mental State Examination) in memory management / managing cognitive impairment?

Clarification of question using PICO structure (PICTRO for diagnostic questions)

Patients: Adults with Cognitive impairment or memory problems
Index Test: MoCA
Comparator Test: MMSE
Reference Standard: Full neuropsychiatric assessment
Outcome: Sensitivity & specificity

Clinical and research implications

Evidence from six diagnostic test accuracy studies indicated that the MoCA is likely to perform as well as or better than the MMSE for the diagnosis of cognitive impairment in a variety of relevant populations. There was also evidence to suggest that the MoCA could be used with a higher diagnostic threshold to maximise sensitivity for screening applications.

Evidence from one study, which analysed the association of individual components of MoCA and MMSE with cognitive impairment, indicated that there may be potential to develop a brief instrument which could have better diagnostic performance than either MoCA or MMSE; further research in this area may be useful.

What does the evidence say?

Number of included studies/reviews (number of participants)
We identified six diagnostic test accuracy studies which compared the performance of the MoCA (Montreal Cognitive Assessment) to that of the MMSE (Mini Mental State Examination for diagnosing cognitive impairment, as defined by neuropsychological testing. One study also assessed the performance of the ACE-R (Addenbrooke's Cognitive Examination–Revised) score.[6] Two studies used a disgnostic case-control design; these studies compared the ability of MMSE and MoCA to distinguish between mild cognitive impairment (MCI) and healthy controls or AD and healthy controls,[2] and between behavioural frontotemporal dementia (bv-FTD) and healthy controls.[3] The

four remaining studies were diagnostic cohorts. Two studies compared the performance of MMSE and MoCA for diagnosing MCI or dementia in a memory clinic population[5] and in participants in the Brain and Body Donation Programme.[1] One study compared MMSE and MoCA for the detection of MCI or dementia in patients with Parkinson disease[4] and the remaining study compared MMSE, MoCA and ACE-R for the detection of MCI in patients one year or more after a transient ischaemic attack (TIA) or stroke.[6]

Main Findings

All studies reported similar[4, 5, 6] or significantly better[1, 2, 3] overall diagnostic performance, as indicated by the area under the receiver operating characteristic (ROC) curve, for MoCA compared to MMSE; one study also reported similar overall performance for ACE-R.[6] The two case-control studies reported that, using optimal diagnostic thresholds for both, MoCA had higher sensitivity and specificity than MMSE in distinguishing patients with MCI, bv-FTD, or AD from healthy controls.[2,3] The reported optimal thresholds to maximise sensitivity and specificity of MoCA for the diagnosis of cognitive impairment were < 24,[1] < 22,[2] and <25.[6] The same studies reported optimal diagnostic thresholds fro MMSE of <28[1] and <29[2] and an optimal threshold for ACE-R of < 94.[6] One study reported that, using a published threshold (≤ 26) MoCA was more sensitive, but less specific than MMSE.[5] Results from the four cohort studies all indicated that the sensitivity of MoCA for cognitive impairment can be maximised (87 to 98%), as might be required in screening settings, by using a higher threshold of 26 or 27.[1, 4, 5, 6]

Of note was the finding by the study of participants in the Brain and Body Donation Programme that a weighted combination of four items from the MoCA and MMSE (2 x MoCAOrientation + MMSE-Recall + MoCA Language + 0.5 x MoCA-Visuospatial-Executive) gave the best overall diagnostic performance. This combination gave a sensitivity of 85% and a specificity of 91% for cognitive impairment using a diagnostic threshold of < 17.[1]

Authors Conclusions

Four of the six studies included in this summary concluded that MoCA was superior to MMSE for the diagnosis of cognitive impairment or dementia,[2, 3, 4, 6] though one stated that a positive result on either instrument required additional confirmation, due to sub-optimal specificity.[4] The remaining two studies concluded that MoCA was a sensitive tool for the diagnosis of cognitive impairment[1,5] and, based on the results of a multivariable analysis of the components of MoCA and MMSE, one also noted the potential for creating an abbreviated MoCA.[1]

Reliability of conclusions/Strength of evidence

The evidence included in this summary was derived from six diagnostic test accuracy studies (four cohort studies and two diagnostic case-control studies). The case-control design is generally associated with a risk of over estimation of index test performance. However, for the studies described here, this risk would be likely to apply equally to MMSE and MoCA, thus the reliability of conclusions about the comparative performance of these two tests is unlikely to be affected by the study design. With one exception,[5] all studies included in this summary reported diagnostic thresholds which were derived within the study population. This approach is usually considered problematic as it may result in over estimations of test performance. However, as with the case-control design, this risk is likely to apply equally to both index tests being assessed and hence is unlikely to bias conclusions about their relative performance. It should also be noted that, in most cases, exploration of the performance of the tests at different operating thresholds was part of the

study aim. Overall, the available studies are of reasonable quality and can be considered to provide a reasonable estimate of the comparative performance of MMSE and MoCA for the diagnosis of cognitive impairment in a variety of relevant populations.

What do guidelines say?

No NICE or SIGN guidelines were found that provide information around the comparative accuracy and utility of the MoCA and the MMSE.

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Date searches conducted: 28/02/2013
Date answer completed:

References

1. Damian AM, Jacobson SA, Hentz JG, et al. *The montreal cognitive assessment and the mini-mental state examination as screening instruments for cognitive impairment: Item analyses and threshold scores.* Dementia and Geriatric Cognitive Disorders 2011;31:126-31.

2. Freitas S, Simoes MR, Alves L, Santana I. *Montreal cognitive assessment: validation study for mild cognitive impairment and Alzheimer disease*. Alzheimer Disease & Associated Disorders 2013;27:37-43.

3. Freitas S, Simoes R, Alves L, Duro D, Santana I. *Montreal Cognitive Assessment (MOCA): Validation study for frontotemporal dementia*. Journal of Geriatric Psychiatry and Neurology 2012;25:146-54.

4. Hoops S, Nazem S, Siderowf AD, et al. Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. Neurology 2009;73:1738-45.

5. Larner AJ. *Screening utility of the montreal cognitive assessment (MoCA): In place of - Or as well as - The MMSE?* International Psychogeriatrics 2012;24:391-6.

6. Pendlebury ST, Mariz J, Bull L, Mehta Z, Rothwell PM. *MoCA, ACE-R, and MMSE versus the national institute of neurological disorders and stroke-canadian stroke network vascular cognitive impairment harmonization standards neuropsychological battery after TIA and stroke*. Stroke 2012;43:464-9.

Results

DTA Primary Studies

Author (year)	Inclusion criteria	Number of participants	Summary of results	Risk of bias
Damian et al, 2011	*Participants* – The participants of this study where participants in the BSHRI Brain and Body Donation Programme. Recruitment to the study was opportunistic, with attempts made to recruit consecutive samples. *Index test 1* - MoCA *Index test 2* - MMSE *Reference Standard* – Standardised neuropsychological battery (Mattis Dementia Rating Scale-2, WMSR Logical Memory, Rey Auditory Verbal Learning Test, Brief Visual Memory Test-Revised, Facial Recognition Test, Token Test, Category Fluency (animals and vegetables), Controlled Oral Word Association Test (CFL), Boston Naming Test-2, WMS-R Digit Span, Trail Making Tests A and B, Stroop, WAIS-III Similarities, WAIS-R Digit Symbol, Clock Drawing Test, Judgment of	N = 135	Aim: To assess the items of MoCA compared with MMSE for the prediction of cognitive impairment, and to examine the characteristics of different MoCA threshold Scores. The age of study participants ranged from 46 to 100 years and their education ranged from 10 to 23 years. The proportion of women was lower in the 'cognitively impaired' group. Neuropsychological testing defined 89 participants as 'cognitively nornal' and 46 as 'cognitively impaired'. Of the 'cognitively impaired' participants, 26 were classified as having mild cognitive impairment (MCI) and 20 as having dementia. Specific diagnoses were: amnestic MCI (n = 13), multidomain amnestic MCI (n = 7), nonamnestic single-domain MCI (n = 5), nonamnestic multidomain MCI (n = 1), probable Alzheimer's disease (n = 2), possible Alzheimer's disease (n = 5), dementia with Lewy bodies (n = 1), Parkinson's disease dementia (n = 4), vascular dementia (n = 3), mixed vascular dementia (n = 1), cognitive impairment due to medication or medical	Within 'external time constraints' participants were recruited consecutively and had unknown cognitive status on recruitment. All tests were conducted within one month, minimising potential for significant progression between tests. Index test and reference standard were appropriate and all participants appear to have received the same reference standard. It was not clear whether those undertaking

	Line Orientation, WAIS-III Block Design, WAIS-III Vocabulary, WAIS-III Information, and the WRAT-3 Reading subtest). Diagnosis of 'cognitively normal' or 'cognitively impaired' was determined by a Neuropsychologist. 'Cognitively impaired' was defined as abnormal performance (-1.5 SD from the age-matched normative mean) on one or more tests. *Target Condition* – Cognitive impairment *Outcome* – Sensitivity and Specificity.		illness (n = 3), and cognitive impairment of undetermined etiology (n = 1). In the majority of participants (number not specified) MoCA and MMSE were completed on the same day; for all participants, all tests were completed within one month. The overall accuracy, as indicated by the area under the receiver operating characteristic (ROC) curve, was greater for MoCA (0.90) than for MMSE (0.82). For this population, ROC analysis indicated an optimum threshold to define cognitive impairment of <28 for MMSE (sensitivity 76%, specificity 75%) and <24 for MoCA (sensitivity 87%, specificity 75%). As might be expected, lowering the diagnostic threshold resulted in increased specificity and decreased sensitivity fro both instruments. Maximum sensitivity (98%) was achieved using MoCA with a diagnostic threshold of <26. Multivariable logistic regression analysis was used to investigate the association of individual MMSE and MoCA items with the presence of cognitive impairment. The results of this analysis indicated that the best overall diagnostic performance was achieved using a weighted combination of 4 items from the MoCA and MMSE (2 x MoCAOrientation + MMSE-Recall + MoCA Language +	neuropsychological testing were aware of MMSE and/or MoCA results and vice versa. Index test thresholds were derived from the study population. However, it should be noted that exploration of optimal operating characteristics was part of the aim of this study.

			0.5 x MoCA-Visuospatial-Executive). This combination gave an AUC of 0.94; for a diagnostic threshold of <17 the sensitivity was 85%, with a specificity of 91%.	
Freitas et al, 2013	*Participants* – Patients were recruited from Coimbre University Hospital Dementia Clinic, with either a diagnosis of mild cognitive impairment, or Alzheimer's dementia. Controls were recruited from a database from an examination of the MoCA for the normative population and were matched to patients for sex, age and education level. Exclusion criteria were higher dementia severity (CDR>2 and MMSE<12 points), recent (previous six months) psychiatric comorbidities or therapeutic changes, and significant motor, visual, or auditory deficits that could alter neuropsychological assessment results. *Index test 1* - MoCA *Index test 2 – MMSE* *Reference Standard* – Neuropsychological assessment	N = 360 (n = 90 MCI, n = 90 AD, and n = 180 cognitively healthy adult controls).	Aim: To validate MoCA for cognitive screening of MCI and AD patients. There were no significant differences in educational level or gender between groups. Participants in the AD group were significantly older than those in the MCI group. Internal consistency was high for both MoCA and MMSE (Cronbach α 0.903 and 0.856, respectively). Over the whole study population, there was a high positive association between MMSE and MoCA scores (r=0.849, P<0.001). For both instruments, scores were significantly lower in the AD group than in the other groups and were significantly lower in the MCI group than in the control group. The overall accuracy for discriminating between MCI and controls, as indicated by the area ROC curve (AUC), was significantly greater for MoCA (0.86 (95% CI: 0.80, 0.90)) than for MMSE (0.75 (95% CI: 0.67, 0.81)). AUC values for discriminating between AD and controls were similar for MoCA (0.98 (95% CI 0.95,	The study used a diagnostic case-control design; it did not recruit a consecutive sample of participants representative of those in whom the tests would be used in clinical practice. The time between tests was not specified, but all assessments appear to have been carried out at baseline. Index test and reference standard were appropriate and all participants appear to have received the same reference standard. However, MMSE appears to have been part of the neuropsychological testing battery which

	battery. (minimum of Mini-Mental State Examination (MMSE), Alzheimer Disease Assessment Scale, Clinical Dementia Rating scale (CDR), Irregular Word Reading Test (TeLPI) for premorbid intelligence estimation, Subjective Memory Complaints scale and Geriatric Depression Scale). The MoCA was never used for diagnostic purposes. Diagnosis was established by multidisciplinary team consensus. The diagnosis of MCI was based on Petersen criteria and the diagnosis of probable Alzheimer's dementia (AD) was based on DSM-IV and the NINCDS-ADRDA criteria. *Target Condition* - Mild cognitive impairment (MCI) or Alzheimer's dementia (AD). *Outcome* – Sensitivity, specificity, positive and negative predictive value, and classification accuracy.		0.99)) and MMSE (0.96 (95% CI: 0.92, 0.98)). For MoCA, the optimal threshold for the diagnosis of MCI was <22; this threshold resulted in sensitivity and specificity estimates of 88% and 77% and positive and negative predictive values of 78% and 80%. All parameters were significantly higher than the corresponding estimates for MMSE used at its optimal threshold (<29). For MoCA, the optimal threshold for the diagnosis of AD was <17; this threshold resulted in sensitivity and specificity estimates of 88% and 98% and positive and negative predictive values of 98% and 89%. All parameters were significantly higher than the corresponding estimates for MMSE used at its optimal threshold (<26). 75 Participants ((35 with MCI and 40 with AD) were re-assessed (mean 176.81±67.09 days after initial assessment) to explore the utility of MoCA and MMSE in monitoring long term cognitive decline. Significant reductions in MoCA scores, between assessments, were seen for all patients and for both the MCI and AD subgroups. In contrast a significant reduction in MMSE score was only observed in the AD group.	formed the reference standard; this may result in incorporation bias and possible over estimation of the diagnostic performance of MMSE. In addition, it was not clear whether those undertaking neuropsychological testing were aware of MMSE and/or MoCA results and vice versa. Index test thresholds were derived from the study population. However, it should be noted that exploration of optimal operating characteristics was part of the aim of this study.
Freitas et al, 2012	*Participants* – Patients were recruited from Coimbre University Hospital Dementia Clinic, with	N = 150 (n = 50 bv-FTD, n = 50 AD, and n = 50	Aim: To validate MoCA as a cognitive screening test for bv-FTD.	The study used a diagnostic case-control design; it did not

	either a diagnosis of the behavioural variant of frontotemporal dementia (bv-FTD), or Alzheimer's dementia (AD). Controls were recruited from a database from an examination of the MoCA for the normative population and were matched to patients for sex, age and education level. Participants were eligible if they had a comprehensive clinical observation, a comprehensive neuropsychological observation with a validated battery, as well as a full investigation using, biochemical, structural and functional imaging. Exclusion criteria were higher dementia severity (CDR>2 and MMSE<12 points), recent (previous six months) psychiatric comorbidities or therapeutic changes, and significant motor, visual, or auditory deficits that could alter neuropsychological assessment results. Patients with aphasic syndromes of FTD or mixed clinical syndromes were also excluded.	cognitively healthy adult controls)	There were no significant differences in age, gender or educational level. In addition, there were no significant differences in baseline MMSE between the two clinical groups. Internal consistency was high for both MoCA and MMSE (Cronbach α 0.906 and 0.832, respectively). Over the whole study population, there was a high positive association between MMSE and MoCA scores (r=0.802, P<0.001). Patients with AD had significantly lower MoCA scores than those with bv-FTD and both clinical groups had significantly lower MoCA scores than the controls. The overall accuracy for discriminating between bv-FTD and controls, as indicated by the area ROC curve (AUC), was significantly greater for MoCA (0.93 (95% CI: 0.87, 0.97)) than for MMSE (0.77 (95% CI: 0.68, 0.85)). Results for AD were not reported. For MoCA, the optimal threshold for the diagnosis of bv-FTD was <17; this threshold resulted in sensitivity and specificity estimates of 78% and 98% and positive and negative predictive values of 98% and 82%. All parameters were significantly higher than the corresponding estimates for MMSE used at its optimal threshold (<26). Results for AD were not reported.	recruit a consecutive sample of participants representative of those in whom the tests would be used in clinical practice. The time between tests was not specified, but all assessments appear to have been carried out at baseline. Index test and reference standard were appropriate and all participants apear to have received the same reference standard. However, MMSE appears to have been part of the neuropsychological testing battery which formed the reference standard; this may result in incorporation bias and possible over estimation of the diagnostic performance

	Index test 1 - MoCA *Index test 2* – MMSE *Reference standard* - Neurological assessment battery (Lisbon Assessment for Dementia). The AD group were additionally assessed using MMSE, the Alzheimer Disease Assessment Scale, the Clinical Dementia Rating scale (CDR), the Irregular Word Reading Test (TeLPI) as an estimate of premorbid intelligence, the Subjective Memory Complaints scale, and the Geriatric Depression Scale (GDS-30). The bv-FTD group were additionally assessed using the Neuropsychiatric Inventory, the Frontal Behavior Inventory, the Comprehensive Affect Testing System, the Frontal Assessment Battery, the MMSE, the Trail Making Test, Verbal Fluency, the Maze-Tracing Task, the Digit Span Test, the Digit Symbol Test, the Spatial Span Test, the Token Test, the Buschke Selective Reminding Test, and the Brief Visuospatial Memory Test.			of MMSE. Neuropsychological testing was interpreted blind to MMSE and MoCA results. Index test thresholds were derived from the study population. However, it should be noted that exploration of optimal operating characteristics was part of the aim of this study.

	Diagnosis was established by a multidisciplinary team, who were blind to MoCA and MMSE scores. The diagnosis of bv-FTD was based on Neary criteria and the diagnosis of probable Alzheimer's dementia (AD) was based on DSM-IV and the NINCDS-ADRDA criteria. *Target Condition* – behavioural frontotemporal dementia (bv-FTD) or Alzheimer's dementia (AD) *Outcome* - Sensitivity, specificity, positive and negative predictive value, and classification accuracy.			
Hoops et al, 2009	*Participants* – Participants were a convenience sample with idiopathic Parkinson Disease (PD) recruited from two movement disorder clinics. Patients who had undergone deep brain stimulation (DBS) within the previous six months were excluded. *Index test 1* - MoCA *Index test 2* – MMSE	N = 132 (no cognitive disorder 92, MCI 23 PD dementia (PDD) 17	Aim: To assess the performance of both MoCA and MMSE to detect MCI and dementia in PD. The mean age of study participants was 65.1 ± 9.7 years, 75.8% were male and 94.7% were white. The mean PD duration was 6.3 ± 5.3 years, and the mean education was 16.4 ± 3.1 years. The median time between MoCA or MMSE and the neuropsychological battery was five weeks. Participants were excluded they completed the battery over six months after the index tests.	The study used a convenience sample (not consecutive or random). Time between index tests and neuropsychological testing was sufficiently short to minimise the possibility of progression. Index test and

	Reference standard - Neuropsychiatric battery (including measures of four cognitive domains: memory (Hopkins Verbal Learning Test [HVLT]), executive abilities (Tower of London-Drexel [TOLDX], Stroop Color-Word Test, and Semantic Verbal Fluency), attention (Backward Digit Span), and visuospatial (Cube Copying, which was extracted from the MoCA and rescored for this purpose). Impairment was defined as ≥1.5 SD below the age-matched normative mean. MCI was defined using modified Petersen criteria and PDD was defined using the recommendations of the Movement Disorder Society Task Force. Diagnoses were determined blind to MoCA and MMSE scores. *Target Condition* – MCI or dementia in Parkinson disease. *Outcome* – Sensitivity and specificity		The overall accuracy for detection of any cognitive disorder, as indicated by the area under the ROC curve, was similar for MoCA (0.79 (95% CI: 0.72, 0.87)) and MMSE (0.76 (95% CI: 0.67, 0.85)). At the optimal screening threshold for MoCA (26/27) the sensitivity and specificity estimates were 90% and 53% and for MMSE (29/30) sensitivity and specificity estimates were 90% and 38%. The reported optimal diagnostic thresholds MoCA and MMSE were 17/18 (sensitivity 18%, specificity 99%) and 24/25 (sensitivity 20%, specificity 99%). The overall accuracy for detection of dementia, as indicated by the area under the ROC curve, was similar for MoCA (0.87(95% CI: 0.79, 0.95)) and MMSE (0.80 (95% CI: 0.67, 0.93)). At the optimal screening threshold for MoCA (24/25) the sensitivity and specificity estimates were 82% and 75% and for MMSE (28/29) sensitivity and specificity estimates were 82% and 63%. The reported optimal diagnostic thresholds MoCA and MMSE were 17/18 (sensitivity 29%, specificity 99%) and 24/25 (sensitivity 29%, specificity 99%). The overall accuracy for detection of MCI, as indicated by the area under the ROC curve, was similar for MoCA (0.74 (95% CI: 0.64, 0.85)) and MMSE (0.72 (95% CI: 0.61, 0.83)). At the optimal screening threshold for MoCA (26/27) the sensitivity and specificity estimates were 83% and 53% and for	reference standard were appropriate and all participants appear to have received the same reference standard. However, information from the MoCA appears to have been part of the neuropsychological testing battery which formed the reference standard; this may result in incorporation bias and possible over estimation of the diagnostic performance of MoCA. Neuropsychological testing was interpreted blind to MMSE and MoCA results. Index test thresholds were derived from the study population.

			MMSE (29/30) sensitivity and specificity estimates were 91% and 38%. The reported optimal diagnostic thresholds MoCA and MMSE were 17/18 and 23/24.	
Larner , 2012	*Participants* – Consecutive patients referred to a memory clinic. *Index test 1* - MoCA *Index test 2* - MMSE *Reference standard* - neuropsychological assessment (including some or all of the following: Wechsler Adult Intelligence Scale Revised, National Adult Reading Test, Wechsler Memory Scale-III, Graded Naming Test, Rey-Osterreith Complex Figure, Stroop color-word test, and verbal fluency tests). MoCA was not used in establishing diagnosis. Petersen criteria and DSM-IV were used to define MCI an dementia.	N = 150	Aim: To assess the clinical utility MoCA, alone or in combination with MMSE, as a screening instrument for cognitive impairment in patients referred to a memory clinic. The median age of participants was 61 years (range 20 to 87 years) and 62% were male. Thirty-six (24%) were classified as having dementia, 29 (19%) had MCI and 85 (57%) had no dementia. MoCA administration was performed independently of, but on the same day as neuropsychological assessment. MoCA and MMSE scores were highly correlated ($r = 0.85$, $p < 0.001$). For both MoCA and MMSE, the mean scores were significantly lower in the cognitively impaired group than in the non-cognitively impaired group, and significantly lower in the dementia group than in the MCI group.	Participants were recruited consecutively. Time between index tests and neuropsychological testing was sufficiently short to rule-out progression. Index test and reference standard were appropriate and all participants appear to have received the same reference standard. However, it was not clear whether those undertaking neuropsychological testing were aware of MMSE and/or MoCA

	Target Condition – cognitive impairment *Outcome* – Specificity, sensitivity.		The overall accuracy for discriminating between cognitively impaired and non-cognitively impaired participants, as indicated by the area ROC curve (AUC), was 0.91 (95% CI: 0.86, 0.95) for MoCA and 0.83 (95% CI: 0.77, 0.90) for MMSE. Using the published diagnostic threshold (≤ 26), MoCA was more sensitive than MMSE (97% and 65%, respectively), but less specific (60% and 89%, respectively). As might be expected, lowering the threshold to ≤ 20 increased the specificity of MoCA (95%), but lowered its sensitivity (63%). Combining MMSE and MoCS, defining a positive result as both test positive or either test positive, did not improve diagnostic performance.	results and vice versa. The index tests were applied using published thresholds.
Pendlebury et al, 2012a	*Participants* – Consecutive, non-institutionalised participants, assessed ≥ 1 year after a transient ischaemic attack (TIA) or stroke as part of a larger polupation study (OXVASC 2002). Participants who had problems that interfered with testing (e.g. poor vision, severe hearing impairment, inability to use the right arm, dysphasia, poor English, or acute illness) were excluded.	N = 91	Aim: To determine the sensitivities and specificities of the MoCA, ACE-R, and MMSE at ≥1 year after transient ischemic attack (TIA) or stroke for detection of MCI. The mean age of study participants was 73.4 ± 11.6 years and 66% were male and 56% were post-stroke. Patients with TIA and stroke were similar in age, education level and gender distribution. Nine participants had incomplete neuropsychology data and three did not have ACE-R. Thirty-nine (42%) participants had MCI (amnestic multiple domain = 10, non-amnestic multiple domain = 9, non-amnestic single domain = 19, amnestic single domain = 1).	Participants were recruited consecutively. Index test and reference standard were appropriate, however, it was not clear whether those undertaking neuropsychological testing were aware of MMSE/MoCA /ACE-R results and vice versa. Index test thresholds

	Index test 1 - MoCA *Index test 2* – MMSE *Index test 3* – ACE-R *Reference standard* - National Institute of Neurological Disorders and Stroke–Canadian Stroke Network Harmonization Standards Neuropsychological Battery (Trail Test parts A and B, Symbol Digit Modalities Test, Boston Naming Test (30-item version), Rey-Osterrieth complex Figure copy, Hopkins Verbal Learning Test-Revised and Letter (Controlled Oral Word Association Test) and category (animals) fluency). Impairment was defined as ≥1.5 SD below the age-matched normative mean and MCI was also defined using Petersen criteria. *Target Condition* – Cognitive impairment *Outcome* – Specificity, sensitivity.		MoCA and ACE-R score were strongly correlated (Spearman $r^2 = 0.76$, $p = 0.0001$). The overall accuracy for discriminating between MCI and non-cognitively impaired participants, as indicated by the area ROC curve (AUC), was 0.85 (95% CI: 0.78, 0.93) for MoCA, 0.83 (95% CI: 0.75, 0.92) for MMSE and 0.90 (95% CI: 0.83, 0.96) for ACE-R. The optimal diagnostic threshold for MoCA was 25 to 26 (MoCA < 25, sensitivity 77% and specificity 83%; MoCA < 26, sensitivity 87% and specificity 63%). The optimal diagnostic threshold for ACE-R was 92 to 94 (ACE < 92, sensitivity 72% and specificity 79%; ACE-R < 94, sensitivity 83% and specificity 73%). The sensitivity of MMSE for MCI was low, only exceeding 70% at a threshold of < 29. Restricting the analysis to multiple-domain MCI gave similar results.	were derived from the study population. The time between the index tests and reference standard was not explicitly reported, but all appear to have been undertaken at the same assessment. Nine participants (<10%) did not complete neuropsychological assessment.

Risk of Bias: SRs

DTA Studies

Study	RISK OF BIAS			
	PATIENT SELECTION	INDEX TEST	REFERENCE STANDARD	FLOW AND TIMING
Damian et al, 2011	☺	☹	?	☺
Freitas et al, 2013	☹	☹	?	☺
Freitas et al, 2012	☹	☹	☺	☺
Hoops et al, 2009	☹	☹	☺	☺
Larner , 2012	☺	?	?	☺
Pendlebury et al, 2012a	☺	☹	?	☺

☺ Low Risk ☹ High Risk ? Unclear Risk

Search Details

Source	Search Strategy	Number of hits	Relevant evidence identified
Guidelines			
NICE	MoCA OR "montreal cognitive"	4	0
Primary studies			
PsycINFO	1. PsycINFO; MMSE.ti,ab; 3599 results. 2. PsycINFO; "mini mental state examination".ti,ab; 5055 results.	27	

	3. PsycINFO; MINI MENTAL STATE EXAMINATION/; 510 results. 4. PsycINFO; 1 OR 2 OR 3; 6280 results. 5. PsycINFO; (sensitivity OR specificity).ti,ab; 71980 results. 6. PsycINFO; (pretest ADJ probability).ti,ab; 24 results. 7. PsycINFO; (pre-test ADJ probability).ti,ab; 14 results. 8. PsycINFO; (post-test ADJ probability).ti,ab; 16 results. 9. PsycINFO; "predictive value*".ti,ab; 5099 results. 10. PsycINFO; "likelihood ratio*".ti,ab; 1163 results. 11. PsycINFO; TEST VALIDITY/; 48133 results. 12. PsycINFO; 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11; 120833 results. 13. PsycINFO; 4 AND 12; 974 results. 14. PsycINFO; dementia.ti,ab; 38655 results. 15. PsycINFO; exp DEMENTIA/; 47041 results. 16. PsycINFO; alzheimer*.ti,ab; 35248 results. 17. PsycINFO; ALZHEIMER'S DISEASE/; 28329 results. 18. PsycINFO; COGNITIVE IMPAIRMENT/; 18936 results. 19. PsycINFO; "cognitive* impair*".ti,ab; 18836 results. 20. PsycINFO; "memory clinic".ti,ab; 513 results. 21. PsycINFO; "memory service".ti,ab; 7 results. 22. PsycINFO; (memory adj2 assess*).ti,ab; 2600 results. 23. PsycINFO; 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22; 80780 results. 24. PsycINFO; 13 AND 23; 812 results. 25. PsycINFO; MoCA.ti,ab; 89 results. 26. PsycINFO; "Montreal Cognitive Assessment".ti,ab; 93 results. 27. PsycINFO; 25 OR 26; 102 results. 28. PsycINFO; 24 AND 27; 27 results.		
EMBASE	29. EMBASE; MMSE.ti,ab; 9839 results. 30. EMBASE; "mini mental state examination".ti,ab;	116	

	8958 results. 31. EMBASE; MINI MENTAL STATE EXAMINATION/; 13449 results. 32. EMBASE; 29 OR 30 OR 31; 19007 results. 33. EMBASE; (sensitivity OR specificity).ti,ab; 762103 results. 34. EMBASE; (pretest ADJ probability).ti,ab; 1046 results. 35. EMBASE; (pre-test ADJ probability).ti,ab; 591 results. 36. EMBASE; (post-test ADJ probability).ti,ab; 402 results. 37. EMBASE; "predictive value*".ti,ab; 80216 results. 38. EMBASE; "likelihood ratio*".ti,ab; 9500 results. 39. EMBASE; SENSITIVITY AND SPECIFICITY/; 184511 results. 40. EMBASE; DIAGNOSTIC ACCURACY/; 168053 results. 41. EMBASE; 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40; 998377 results. 42. EMBASE; 32 AND 41; 2096 results. 43. EMBASE; dementia.ti,ab; 79426 results. 44. EMBASE; exp DEMENTIA/; 204396 results. 45. EMBASE; alzheimer*.ti,ab; 105250 results. 46. EMBASE; ALZHEIMER'S DISEASE/; 112076 results. 47. EMBASE; COGNITIVE IMPAIRMENT/; 84503 results. 48. EMBASE; "cognitive* impair*".ti,ab; 38779 results. 49. EMBASE; "memory clinic".ti,ab; 976 results. 50. EMBASE; "memory service".ti,ab; 9 results. 51. EMBASE; (memory adj2 assess*).ti,ab; 2960 results. 52. EMBASE; 43 OR 44 OR 45 OR 46 OR 47 OR 48 OR 49 OR 50 OR 51; 295447 results. 53. EMBASE; 42 AND 52; 1819 results. 54. EMBASE; MoCA.ti,ab; 653 results.		

	55. EMBASE; "Montreal Cognitive Assessment".ti,ab; 494 results. 56. EMBASE; 54 OR 55; 736 results. 57. EMBASE; 53 AND 56; 116 results.		
MEDLINE	58. MEDLINE; MMSE.ti,ab; 5551 results. 59. MEDLINE; "mini mental state examination".ti,ab; 6646 results. 60. MEDLINE; MINI MENTAL STATE EXAMINATION/; 0 results. 61. MEDLINE; 58 OR 59 OR 60; 8724 results. 62. MEDLINE; (sensitivity OR specificity).ti,ab; 657299 results. 63. MEDLINE; (pretest ADJ probability).ti,ab; 784 results. 64. MEDLINE; (pre-test ADJ probability).ti,ab; 349 results. 65. MEDLINE; (post-test ADJ probability).ti,ab; 310 results. 66. MEDLINE; "predictive value*".ti,ab; 61059 results. 67. MEDLINE; "likelihood ratio*".ti,ab; 7691 results. 68. MEDLINE; SENSITIVITY AND SPECIFICITY/; 257105 results. 69. MEDLINE; 62 OR 63 OR 64 OR 65 OR 66 OR 67 OR 68; 844325 results. 70. MEDLINE; 61 AND 69; 1151 results. 71. MEDLINE; dementia.ti,ab; 58929 results. 72. MEDLINE; exp DEMENTIA/; 108763 results. 73. MEDLINE; alzheimer*.ti,ab; 80433 results. 76. MEDLINE; "cognitive* impair*".ti,ab; 27405 results. 77. MEDLINE; "memory clinic".ti,ab; 622 results.	41	

	78. MEDLINE; "memory service".ti,ab; 6 results. 79. MEDLINE; (memory adj2 assess*).ti,ab; 2277 results. 80. MEDLINE; ALZHEIMER DISEASE/; 60754 results. 81. MEDLINE; MILD COGNITIVE IMPAIRMENT/; 849 results. 82. MEDLINE; 71 OR 72 OR 73 OR 76 OR 77 OR 78 OR 79 OR 80 OR 81; 164792 results. 83. MEDLINE; 70 AND 82; 953 results. 84. MEDLINE; MoCA.ti,ab; 277 results. 85. MEDLINE; "Montreal Cognitive Assessment".ti,ab; 178 results. 86. MEDLINE; 83 AND 85; 41 results.		
Summary	**NA**	**NA**	

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