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Screening for Cognitive Impairment with the Quick Memory Check: Validation of a Caregiver Administered Cognitive Screen.

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Abstract

Background: Self or home-administered cognitive screening instruments (CSIs) can reduce barriers to the early detection of mild cognitive impairment (MCI) and dementia.

Objective: To examine the acceptability and diagnostic accuracy of a caregiver-administered CSI, the Quick Memory Check (QMC).

Methods: Components of the Quick Mild Cognitive impairment (Q*mci*) screen, (orientation, verbal fluency and logical memory) were re-weighted to create the QMC, scored out of 100 points. Participants, attending a university hospital memory clinic were provided administration instructions beforehand. Area under the curve (AUC) scores, adjusted for age and education, were compared with the Q*mci* screen and Montreal Cognitive Assessment (MoCA). Caregivers or family scored the QMC.

Results: In all, 366 participants were recruited; 53 with subjective memory complaints (SMC), 74 with MCI, 193 with dementia and 46 normal controls. Median QMC scores for controls were 70±13 versus 60±20 for SMC, 52±18 for MCI and 31±21 for dementia. The QMC had excellent accuracy (AUC 0.97) for cognitive impairment (MCI/dementia from controls), similar to the Q*mci* screen (AUC 0.98,p=0.17) and MoCA (AUC 0.95, p=0.13). At a cut-off of <52/100, the QMC had 83% sensitivity and 100% specificity for cognitive impairment. The QMC had lower accuracy differentiating MCI from SMC (AUC 0.73), albeit similar to the MoCA (AUC 0.70).

Conclusions: The QMC, administered by caregivers in advance of clinic, compared favourably to established CSIs scored by trained raters. This caregiver, home-administered CSI is acceptable and can identify cognitive impairment, potentially improving efficiency by reducing testing time and patient stress in busy clinical settings.

Key words: Cognitive screening instrument, caregiver, mild cognitive impairment, diagnostic accuracy testing, dementia

Introduction

With the prevalence of dementia set to increase worldwide [1] and the potential for new disease-modifying treatments [2], busy healthcare practitioners require efficient and effective instruments to screen for cognitive impairment (CI) when patients with suggestive symptoms are referred for evaluation. There is however, insufficient evidence to recommend any single short cognitive screening instrument (CSI) [3,4]. Instruments should ideally be short, accurate, easy to interpret and administer with minimal supervision [5]. A wide variety of performance-based instruments are available, varying in their administration times, cognitive domains assessed and ability to differentiate between normal cognition, mild cognitive impairment (MCI) and dementia [5,6], though it is suggested that none will fit all situations [5].

Traditionally, cognitive screens can be divided into performance-based instruments scored by trained raters, or informant-based observer rated scales, both administered in a clinical setting. Informant-based CSIs, administered in conjunction with family or caregivers, provide a collateral, documenting symptoms suggestive of CI. Although widely validated, they are long and may not be accurate in detecting decline in cognition over time [7]. Informant-based scales should be interpreted with caution as ageing caregivers may have cognitive difficulties themselves, or may know the patient too well or insufficiently to be objective [8].

Another method of testing cognition is with home or self-assessment. Interest in self-diagnosis including home-administered screening is increasing [9,10]. It is suggested that this has several potential advantages. Psychosocial stress is known to impair memory retrieval [11,12] and there is evidence [13], albeit conflicting [14], that anxiety affects performance on neuropsychological testing. While white coat effects are well-established in hypertension, white coat effects related to the administration of CSIs are less well-established and little is known about their effect on patients with CI. Home-administration in a familiar setting could potentially reduce the anxiety associated with assessment in busy clinics. Further, as time is limited in clinical practice, assessment prior to clinic may reduce waiting times. There is also evidence that performance on CSIs fluctuates over short intervals [15]. Home-administration may identify variation in patient scoring, allowing more frequent assessments at different time intervals, capturing variability that may suggest the presence of subtle CI or delirium [16]. With the growing use and availability of technology worldwide, particularly on mobile devices, there has been an increase in online and telephone self-administered tests for MCI and dementia [17]. These have been shown to be feasible and accurate [17]. Instruments such as the Test Your Memory (TYM) instrument [18], the most widely studied self-administered cognitive screen is scored under supervision of trained raters, and has been validated in memory clinics against established instruments [18,19]. Other validated self-administered tests include the Computerized Self Test (CST) [20] and the Self-Administered Gerocognitive Examination (SAGE) [21,22]. Informant based Tests such as the Cambridge Behavioural Inventory are another possibility [23].

While self-administered CSIs have been studied, a recent systematic review highlighted that most still require some supervision and uncertainty remains over their feasibility and validity compared with clinic assessment [24]. A potential solution to this is to utilise caregivers or those close to patients as raters. Although there is evidence that caregivers actively wish to engage with the diagnosis [25], little information is available on the ability or willingness of caregivers to administer CSIs. To our knowledge, no instruments scored by caregivers have been validated. Given the increasing use of "home-administered" cognitive screens, we sought to develop and

validate a caregiver-administered CSI, the Quick Memory Check (QMC), which when scored prior to clinic can be used in conjunction with comprehensive healthcare assessment to diagnose CI.

Methods

The Quick Memory Check

The QMC is based upon the Quick Mild Cognitive Impairment (Q*mci*) screen [26]. The Q*mci* screen is a short (less than five minutes) CSI composed of six subtests, covering five domains: orientation (country, year, month, day and date), registration (5-word), clock drawing, (5-word) delayed recall, verbal fluency (naming in one minute) and logical memory (immediate verbal recall of a short story within 30 seconds), scored out of 100 points [27]. In several clinical studies [28,29] and two recent systematic reviews [30,31], the Q*mci* screen had similar accuracy compared to the Montreal Cognitive Assessment (MoCA) in identifying MCI [31], but with greater specificity, albeit slightly lower sensitivity [29]. The Q*mci* correlates with the Standardised Alzheimer`s Disease Assessment Scale-cognitive section (r=-0.80) and Clinical Dementia Rating Scale (-0.54) in a secondary analysis of a randomised controlled trial including persons with mild-moderate dementia [32]. Previous analyses of the Q*mci* subtests revealed that verbal fluency and logical memory subtests best differentiated MCI from normal controls (NC), while orientation best differentiated MCI from dementia [27]. Based upon this analysis, a consensus meeting between the lead researchers was held to shorten and reweight the Q*mci* screen to produce the QMC. The accuracy of this version was tested in an existing dataset [26] and piloted with caregivers and patients in clinic [33]. Orientation was increased to 15 points (from 10 points), verbal fluency (for animals as initial piloting found that animals were the easiest to score) from 20 to 40 points and logical memory from 30 to 45 points. The QMC can be completed in under three minutes. The QMC along with scoring instructions are provided in Appendix 1.

Participants

This study was conducted parallel to a study evaluating the Q*mci* screen in an Irish memory clinic population [28]. The methods have been published previously elsewhere [28] but in summary, consecutive patients attending an Irish university hospital memory clinic (Cork City) were screened and assessed for CI. All patients had a detailed assessment including history, physical examination and work-up for causes of CI including a brain computerised tomogram or MRI brain, an electrocardiogram and blood tests. A battery of cognitive tests including the Standardised Mini-Mental State Examination (SMMSE) [34,35], AD8 questionnaire [36] and the Informant Questionnaire on Cognitive Decline in the Elderly-short form [37], were used to inform the diagnosis independent of the results of the QMC and comparator tests. Severity was correlated with the Reisberg FAST scale [38]. Patients were classified as having subjective memory complaints (SMC), MCI or dementia. Dementia was diagnosed using Diagnostic and Statistical Manual of Mental Disorders, (4th edition) criteria [39]. MCI was diagnosed clinically using Petersen's criteria [40] supported by the National Institute on Aging-Alzheimer's Association workgroup diagnostic guidelines [41]. SMC was defined where patients were found to have subjective but non-progressive memory complaints without objective cognitive deficits or functional decline, while scoring 'poor' or 'fair' on a five-point Likert scale in response to the question "how is your memory?" [42]. Normal Controls (NCs) were recruited by convenience sampling from healthy participants (older volunteers recruited from local bridge – the card game - and active ageing clubs) without cognitive problems (self-reporting good to excellent

memory), provided they had another individual in the household to administer the QMC to them. These completed the battery of CSIs with trained raters in the community but did not attend clinic for a formal assessment unless deficits were detected in which case their primary provider was contacted with their consent. Patients were excluded if they were aged ≤45 years, actively depressed (diagnosed clinically) or unable to provide a caregiver (child, spouse or other unrelated individual providing support to the patient) to administer the screen. Depression was diagnosed clinically in clinic using the Geriatric Depression Scale short-form [43]. Patients with all dementia subtypes were included in this analysis to minimise risk of selection and spectrum bias and to increase the generalisability of the findings.

Data Collection

Data were collected between January 2013 and December 2014. The QMC with scoring instructions was posted with the clinic appointment letter in advance of attendance. The scoring instructions, posted with the QMC, stipulated that the test be dated (including time of day) and completed prior to attending clinic (within a week of attendance). Caregivers were asked to provide their personal details including age, sex, occupation, educational level and time spent with the patient (days per week) on the form. In clinic, each patient had demographic data collected including age, sex and number of years of education. As part of the main study, each patient had the Q*mci* screen and MoCA administered sequentially but randomly by two trained clinician raters, blind to the final diagnosis. The MoCA is a short cognitive screen with seven subtests covering five cognitive domains: memory, language, visuospatial, attention/processing speed, and cognitive control, scored out of 30 points [44].

Inter-rater reliability (IRR) was determined by comparing the whole QMC (all subtests) completed at home to a repeat performed by a clinic nurse on arrival, for a sample of patients chosen by simple randomisation (n=30). Test-retest reliability was assessed on a similar number of patients who had the QMC scored a second time in clinic by the same carer but under supervision by clinic staff. Alternative forms of the tests were used to reduce learning effects and bias for those completing reliability testing [45]. Caregiver satisfaction with scoring the QMC was measured using an anonymous, self-completed questionnaire developed by the researchers. Caregivers were asked ten questions based on a five-point Likert scale scored from strongly agree to strongly disagree regarding their experience using the QMC. This incorporated questions on their understanding of the instructions, ease of use and willingness to administer it again. Their characteristics were also recorded to provide context to the results of the questionnaire. This study adhered to the tenets of the Declaration of Helsinki. Ethics approval was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospitals (Ref ECM 4 ww 03/07/12). Both patients and caregivers provided informed written consent where possible. In the case of patients with dementia, where capacity was considered by the attending physician to be absent, assent was obtained in accordance with current Irish law.

Statistical analysis

Data were analysed using SPSS version 24.0 (Chicago, IL, USA) and R version 4.1.3 (R Core Team 2022, Vienna, Austria). The Shapiro–Wilk test was used to test normality and found that the majority of data were non-parametric. The accuracy of the individual screening tests was determined from the area under the curve (AUC) using receiver operating characteristics (ROC) curves, which were compared using the DeLong method [46]. Covariate adjusted ROC curves were generated to assess for the effects

of age and education. Youden's Index was used to calculate cut-off scores for the QMC [47]. Sensitivity, specificity, positive predictive value (PPV), negative predictive values (NPV), likelihood ratios were calculated for each CSI. Pearson's correlation was used to assess IRR and test-retest reliability.

Results

Participant characteristics

In total, 395 participants were available. Of these, 266 were included; 320 patients and 46 controls. A further 29 participants were excluded because of missing data (n=2), refusal to consent (n=2), unclear diagnosis (n=2), active depression (n=14) and age <45 years (n=9). Of those included, 53 had SMC, 74 MCI and 193 dementia. Patient selection is presented in Table 1 and graphically in Figure 1. Most patients with dementia had early-mild dementia (n=142, 74%); the remainder had moderate (n=41) or severe (n=10) dementia. The majority were diagnosed with possible or probable Alzheimer's disease (AD) (n=127, 66%), followed by vascular dementia (VaD) (n=30), mixed AD-VaD (n=17), LBD (n=7), FTD (n=5), other/unknown (n=5) and PDD (n=2). Most patients with MCI (n=64/74, 86.5%) were classified as having amnestic type MCI.

The median age of the participants included was 75 years, interquartile range (IQR) ±12. They had a median SMMSE score of 26, IQR ±8. Of these, 228 (62%) were female. The median time spent in formal education was 12 (±4) years. Patients with dementia were similar in age to those with MCI (p=0.05), but were significantly older than those with SMC (p=0.03) and NCs (p<0.001). There was no difference in age between controls and patients presenting with SMC (p=0.39).

Caregiver (rater) characteristics

The median age of 'caregiver' raters (i.e. those scoring the participants) was 53 years (IQR ±26), and most were female (68%). The level of education among caregivers was high with 49% completing third level. Only 9% of caregivers had finished education at primary level and 42% secondary level. The majority of those scoring the QMC identified as the child of the participant (47.5%), followed by their spouse (39%) and other relationship (14%) which included friends, other relatives and family doctors. The 'caregiver rater' was currently in employment in 49% of cases, retired in 25% and working within the home, including those who describing themselves as unemployed or full-time carers, in 26% of cases.

Comparative performance of the QMC

The median score for all participants on the QMC was 43/100. The median QMC score for controls was 70 points (±13) compared to 60 (±20) for patients with SMC, 52 (±18) for MCI and 31 (±21) for dementia (p<0.001). Median scores for the outcome measures are presented in Table 1. The median duration between home testing and attending clinic was 30 days. Test-retest reliability was 0.95 and IRR was 0.82. Median administration time for a sample of 30 patients, timed in clinic, was 2.5 minutes.

In its ability to differentiate patients with MCI from NCs, the QMC with an AUC of 0.91 (95% confidence interval: 0.85–0.96) had statistically similar accuracy to the Q*mci* screen, AUC 0.94 (95% confidence interval: 0.89–0.98), p=0.44. It also had slightly higher, albeit statistically similar accuracy to the MoCA (AUC 0.85, p=0.21). In separating CI from SMC, the QMC had good accuracy (AUC 0.88), comparing favourably with the MoCA (AUC 0.89, p=0.98), albeit less accurate than the Q*mci* screen (AUC 0.95, p=0.006). Each of the cognitive assessments separated CI

(MCI/Dementia) from NCs; the QMC provided an AUC of 0.97 (95% confidence interval: 0.95–0.99), again similar to the Q*mci* (AUC 0.98, p=0.17) and MoCA (0.95, p=0.13). The QMC had good accuracy in its ability to differentiate MCI from dementia with an AUC of 0.81 (95% confidence interval: 0.75–0.88), although this was less accurate than both the Q*mci* screen (AUC 0.94, p<0.001), and MoCA (AUC 0.90, p=0.03). ROC curve values are presented in Table 2 and Figure 2. The age and education adjusted AUC values for each CSI were similar and are presented in Table 2. These showed that any differences in discriminative ability were small and not due to the effects of age or education (multiple R^2 values <5% i.e. between 0.00-0.04).

Cut-off scores for the QMC

Using Youden's Index [47], the optimal QMC cut-off score for separating CI from NCs was ≤52. At this cut-off, the QMC had 83% sensitivity and 100% specificity for CI. It had a PPV of 100% and NPV of 50%. The optimal cut-off that differentiated MCI from NCs was 63, yielding a sensitivity of 89% and specificity of 78%. The cut-off that best differentiated dementia from MCI was ≤40 with a sensitivity and specificity of 75%. Cut-off scores for all four CSIs compared are presented in Table 3 with their corresponding sensitivity, specificity, NPV, PPV, false positive and negative rates and likelihood ratios.

Acceptability

In all, 100/366 (response rate 27.3%) caregivers completed the questionnaire. The results suggest that the majority of caregivers found the QMC acceptable with most agreeing or strongly agreeing that it was easy to read (98%) understand (90%), and to score (80%). Most (84%) were agreeable to scoring it again and only a few respondents (10%) reported that it was too time consuming. Results of the questionnaire are shown in Figure 3.

Discussion

This study reports the clinimetric properties and diagnostic accuracy of the QMC, a new, home-administered, caregiver-rated short CSI, administered in advance of clinic to patients attending with symptomatic memory loss. It compares the properties and performance of the QMC to a selection of CSIs including the widely-used MoCA, demonstrating strong concurrent validity. The QMC when scored by carers who were predominantly family members had similar, good to excellent, diagnostic accuracy for differentiating CI (MCI or dementia) from NCs (AUC 0.91), comparing well against the MoCA and Q*mci* screen, administered in clinic by trained raters. Examining the literature, its accuracy for CI compared well with the results of short self-administered instruments available including the SAGE (AUC 0.92) [21] and the TYM (AUC of 0.94) [19], which are scored by patients themselves under supervision in clinic settings. The TYM, like the QMC is recommended for use in non-clinical, non-specialised settings [48]. Further study is required to compare the QMC with the TYM and similar instruments, which could also potentially be scored by caregiver raters, though to date such CSIs have not been examined with this group.

The QMC had good accuracy in distinguishing SMC from CI (AUC 0.88), important as patients with SMC often present to primary care where time for screening for MCI an established barrier [49] or seek out information there, such that they are arguably the most likely group to complete the QMC at home. In contrast, the it had only fair accuracy in separating SMC from MCI (AUC 0.73), likely reflecting the more subtle differences in scores when patient with dementia are excluded. This said, it had

similar ability to the MoCA (AUC 0.70), albeit it was less accurate than the Q*mci* screen (AUC 0.83). While the QMC has good accuracy (AUC 0.81) for separating those with MCI from dementia, it was statistically significantly less accurate than the MoCA and Q*mci* screen. It is not clear why accuracy was relatively low for differentiating these groups but may represent challenges administering the tests in those with dementia, particularly more moderate to severe disease. Irrespective, it is less likely that the QMC will be required to separate patients with MCI and dementia as this distinction relates to function rather than scores on CSIs.

The accuracy of the QMC was not influenced by the effect of patient age or education level including when separating MCI from dementia. Based upon the results we would recommend a cut-off score of ≤52 for differentiating CI from normal cognition. At this score the QMC had 83% sensitivity and 100% specificity. The optimal cut-off for MCI was ≤63 compared to ≤40 for dementia. This study also supports evidence suggesting that the existing cut-off score for the MoCA (<26 for CI) is too high [28,50,51] and should be adjusted lower to optimize accuracy.

Home-administered instruments offer the advantage of allowing patients to complete cognitive screening away from the busy atmosphere of clinic, potentially minimising "white-coat" effects associated with attending and being tested in clinical environments. However, unlike self-administered tests that are usually conducted under clinic supervision, physicians cannot see and assess the conditions under which the QMC was administered. Further, home testing may strain relationships between patients and carers. This said, raters did not report this when questioned. Caregivers were satisfied with scoring the QMC with the majority agreeing that it was easy to administer and that they would be happy to score it again. This may be because the QMC is intuitive and quick to score with markedly shorter administration times (2.5 minutes) compared with CSIs such as the TYM [18] and SAGE [21], which take 10-15 minutes. This brevity does not appear to be at the expense of accuracy based on the comparative analysis presented here. However, the authors must stress that the QMC is conceptualised only as an aid to support clinical interactions between patients, partners, families and healthcare professionals akin to home blood pressure or glucose monitoring. It is not a substitute for formal cognitive screening or neuropsychological assessment and should not be used alone to inform a diagnosis. Its use without more detailed evaluation by a trained healthcare professional would be inappropriate and could potentially be unethical.

Limitations

This study has a number of limitations. The prevalence of cognitive impairment was high in this sample with only 46 NCs available. This may have resulted in spectrum bias. Given the potential challenges of completing this at home in advance of clinic, those caregivers who agreed to participate may have been systemically different, resulting in selection bias. This said, carers were predominantly middle aged female (daughters), with at least secondary level education, most commonly related to the patients. More detailed information on all caregivers, relatives or informants attending with patients including those who declined to participate would allow better understanding of whether this influenced the results. While IRR, comparing carer and clinic raters was strong (r=0.82), it was not perfect and was low compared with test-retest reliability (r=0.95), comparing results at home versus in clinic scored by carers but under supervision, suggesting that instructions provided to caregivers, posted with the QMC in advance of the clinic may require enhancing. A training and administration video hosted by our university website is now planned to examine if this will increase

reliability. Further, the median administration time obtained in clinic may not reflect the time taken by caregivers. Although satisfaction with the test appeared excellent overall, the low response rate suggests that this should be viewed with caution. Finally, this study was performed at a single centre, potentially reducing the generalisability of the findings.

Conclusion

In summary, the QMC is the first home-administered cognitive screen validated for use by caregivers. It is short (median 2.5 mins), acceptable, and has concurrent validity compared to a battery of short CSIs scored in clinic. It is easy-to-use and can be administered in an informal setting without direct clinical supervision. The QMC suggests that caregiver-administered cognitive screening tests may be useful in combination with traditional clinic-based assessments, particularly if conducted as a pre-assessment at home prior to attending. It could accordingly reduce testing time and patient stress ("white coat" effect), potentially generating scores more reflective of patients true cognition. It could also be useful as a pre-screen for early cognitive impairment in community settings, for example as part of screening initiatives in primary care [52]. Irrespective, the QMC should be used as part of a more detailed assessment to confirm a diagnosis of cognitive impairment rather than as a stand-alone test. Further research is now required to confirm these findings. In particular, the QMC should now be compared in different clinical settings including primary practice, where the test could arguably be best suited. Future research should also compare it to self-administered screens such as the TYM and SAGE.

Conflict of interest

Dr. Rónán O'Caoimh and Prof. D. William Molloy are co-copyright holders of the Quick Memory Check and Quick Mild Cognitive Impairment Screen. The authors report no other conflict of interest.

Tables

Table 1. Characteristics of the total sample, controls, those with subjective memory complaints (SMC), mild cognitive impairment (MCI), dementia and cognitive impairment (CI) groups, including median Quick Memory Check (QMC), Quick Mild Cognitive Impairment screen (Q*mci*), and Montreal Cognitive Assessment (MoCA) scores with inter-quartile range (IQR), (Q1–Q3 = IQR; Q1 = 1st Quartile, Q3 = 3rd Quartile).

Group	Total	Controls	SMC	MCI	Dementia	CI
Number of assessments	n=366	n=46	n=53	n=74	n=193	n=267
Age (years)						
Median	75	72	72	75	77	76
IQR	(81-69=12)	(77-65=12)	(81-66=15)	(80-70=10)	(81-71=10)	(81-70=11)
Range	46-92	58-85	46-89	59-91	48-92	48-92
Education (years)						
Median	12	14	12	12	11	11
IQR	(14-10=4)	(17-12=5)	(14-10=4)	(14-10=4)	(13-10=3)	(13-10=3)
Range	7-18	8-18	8-18	8-18	7-18	7-18
QMC (median with IQR)	43 (59-30=29)	70 (78-65=13)	60 (74-54=20)	52 (59-41=18)	31 (40-10=20)	36 (47-23=24)
Q*mci* screen (median with IQR)	49 (63-33=30)	75 (82-67=15)	66.5 (72-62=10)	56 (62-51=11)	36 (45-22=23)	42 (52-26=26)
MoCA (median with IQR)	19 (24-12=12)	27 (29-24=5)	24 (26-22.5=3.5)	22 (24-20=4)	13 (17-7=10)	16 (21-9=12)

Table 2. Comparison of area under the curve (AUC) values with 95% confidence intervals, unadjusted and adjusted for age and education, for the Quick Memory Check (QMC), Quick Mild Cognitive Impairment (Q*mci*) screen and Montreal Cognitive Assessment (MoCA) in their ability to differentiate cognitive impairment (CI) from normal controls (NCs), mild cognitive impairment (MCI) from NC, MCI from subjective memory complaints (SMC), MCI from dementia, and dementia from MCI and SMC.

Diagnosis	**Test**	**AUC**	**95% Confidence Interval**	**Adjusted AUC***	**95% Confidence Interval***	**Multiple R^2**	**p=**
a. MCI from NCs	QMC	0.91	0.85-0.96	0.88	0.82-0.94	0.02	0.58
	Q*mci*	0.94	0.89-0.98	0.93	0.88-0.97	0.04	0.33
	MoCA	0.85	0.77-0.92	0.83	0.75-0.90	0.04	0.35
b. MCI from SMC	QMC	0.73	0.64-0.83	0.73	0.63-0.82	0.02	0.57
	Q*mci*	0.83	0.75-0.91	0.85	0.77-0.92	0.04	0.33
	MoCA	0.70	0.60-0.80	0.71	0.62-0.80	0.04	0.35
c. CI (MCI and dementia) from NCs	QMC	0.97	0.95-0.99	0.96	0.93-0.98	0.03	0.03^
	Q*mci*	0.98	0.97-0.99	0.96	0.94-0.98	0.02	0.08
	MoCA	0.95	0.92-0.98	0.92	0.88-0.95	0.03	0.06
d. MCI from Dementia	QMC	0.81	0.75-0.88	0.80	0.73-0.87	0.01	0.34
	Q*mci*	0.94	0.91-0.97	0.92	0.89-0.95	0.00	0.81
	MoCA	0.90	0.75-0.88	0.90	0.86-0.93	0.00	0.67
e. Dementia (from MCI & SMC)	QMC	0.87	0.82-0.91	0.86	0.81-0.90	0.01	0.36
	Q*mci*	0.97	0.95-0.98	0.95	0.93-0.97	0.00	0.84
	MoCA	0.92	0.89-0.95	0.92	0.89-0.95	0.00	0.71
f. CI (MCI and dementia) from SMC	QMC	0.88	0.83-0.93	0.87	0.82-0.92	0.03	0.03^
	Q*mci*	0.95	0.92-0.98	0.93	0.91-0.95	0.02	0.09
	MoCA	0.89	0.84-0.93	0.88	0.84-0.91	0.02	0.06

*Adjusted for age and education
^ Statistically significant

Table 3. Comparison of cut-off scores based upon Youden's Index for the Quick Memory Check (QMC) and Quick Mild Cognitive Impairment (Q*mci*) screen and Montreal Cognitive Assessment (MoCA) to differentiate cognitive impairment (CI) from normal controls (NCs), mild cognitive impairment (MCI) from NC, MCI from dementia and dementia from MCI and subjective memory complaints (SMC), including sensitivities, specificities, positive predictive values (PPV), negative predictive values (NPV), positive likelihood ratio (PLR) and negative likelihood ratio (NLR) weighted by prevalence, and 95% confidence intervals at each cut-off.

Diagnosis	**Test**	**Cut-off Score**	**Sensitivity** (95% confidence interval)	**Specificity** (95% confidence interval)	**PPV** (95% confidence interval)	**NPV** (95% confidence interval)	**False Positive** (95% confidence interval)	**False Negative** (95% confidence interval)	**PLR** (95% confidence interval)	**NLR** (95% confidence interval)
Prevalence of CI of 85% (81-89)										
NCs from CI (MCI & dementia)	QMC	≤52 (<53)	83% (77-87)	100% (90-100)	100% (98-100)	50% (39-61)	0% (0-0)	50% (39-61)	NA	1.0 (0.8-1.25)
	Q*mci* screen	≤60 (<61)	91% (87-94)	96% (84-99)	99% (97-100)	66% (53-77)	0% (0-0)	34% (23-47)	120 (30-477)	0.5 (0.4-0.7)
	MoCA	≤23 (<24)	90% (85-93)	85% (71-93)	97% (93-99)	62% (49-74)	3% (1-7)	38% (26-51)	30 (14.5-62.5)	0.6 (0.4-0.9)
Prevalence of MCI of 62% (52-70)										
MCI from NCs	QMC	≤63 (<64)	89% (79-95)	78% (63-89)	87% (76-93)	82% (67-91)	13% (7-24)	18% (9-33)	6.5 (3.6-11.7)	0.2 (0.1-0.4)
	Q*mci* screen	≤68 (<69)	95% (86-98)	74% (59-85)	85% (75-92)	89% (74-97)	15% (8-25)	10% (3-26)	5.8 (3.4-9.8)	0.1 (0-0.3)
	MoCA	≤24 (<25)	80% (67-89)	72% (56-84)	78% (65-88)	73% (58-85)	22% (12-35)	27% (15-42)	3.6 (2.2-6.0)	0.4 (0.2-0.6)
Prevalence of MCI of 58% (49-67)										
MCI from SMC	QMC	≤57 (<58)	71% (59-81)	68% (54-80)	75% (63-85)	63% (49-75)	25% (15-37)	37% (25-51)	3.1 (2.0-4.7)	0.6 (0.4-0.8)
	Q*mci* screen	≤59 (<60)	66% (54-76)	90% (78-96)	91% (79-96)	65% (53-76)	9% (4-21)	35% (24-47)	9.6 (4.1-22)	0.5 (0.4-0.7)
	MoCA	≤22 (<23)	59% (46-72)	75% (60-85)	73% (58-84)	61% (48-73)	27% (16-42)	39% (27-52)	2.7 (1.6-4.4)	0.6 (0.45-0.9)
Prevalence of Dementia of 72% (66-78)										
MCI from Dementia	QMC	≤40 (<41)	75% (69-81)	75% (64-84)	89% (83-93)	54% (44-64)	11% (7-17)	46% (36-56)	8 (5.2-12.4)	0.9 (0.7-1.1)
	Q*mci* screen	≤49 (<50)	90% (85-94)	88% (77-94)	95% (90-98)	77% (66-85)	5% (2-10)	23% (15-34)	19 (10-36)	0.3 (0.2-0.4)
	MoCA	≤16 (<17)	71% (64-77)	95% (85-99)	98% (93-99)	52% (43-62)	2% (1-7)	48% (38-57)	42 (13.6-128)	0.9 (0.7-1.1)
Prevalence of Dementia of 60% (55-66)										
Dementia (from MCI & SMC)	QMC	≤48 (<49)	91% (86-95)	69% (60-77)	82% (76-87)	84% (75-90)	18% (13-24)	16% (10-25)	4.5 (3.3-6.0)	0.2 (0.1-0.3)
	Q*mci* screen	≤49 (<50)	90% (85-94)	91% (84-95)	94% (89-97)	86% (78-91)	6% (3-11)	14% (9-22)	15.5 (8.8-25.6)	0.2 (0.1-0.3)
	MoCA	≤17 (<18)	76% (68-82)	93% (86-97)	94% (89-97)	70% (62-77)	6% (3-11)	30% (23-38)	16.6 (8.5-32.6)	0.4 (0.3-0.5)
Prevalence of CI of 83% (79-87)										
SMC from CI (MCI and dementia)	QMC	≤49 (<50)	79% (73-83)	83% (70-91)	96% (92-98)	44% (34-54)	4% (2-8)	56% (46-66)	4.6 (2.5-8.4)	0.3 (0.2-0.32)
	Q*mci* screen	≤56 (<57)	86% (81-90)	92% (81-98)	98% (95-99)	57% (46-68)	2% (1-5)	43% (32-54)	11.2 (4.4-28.8)	0.15 (0.1-0.2)
	MoCA	≤21 (<22)	77% (71-83)	82% (69-91)	95% (91-98)	44% (34-55)	5% (2-9)	46% (55-66)	4.4 (2.4-8)	0.3 (0.2-0.35)

Figures

Figure 1. Study flow chart detailing participant recruitment including normal controls and those with subjective memory complaints (SMC), mild cognitive impairment (MCI) and dementia.

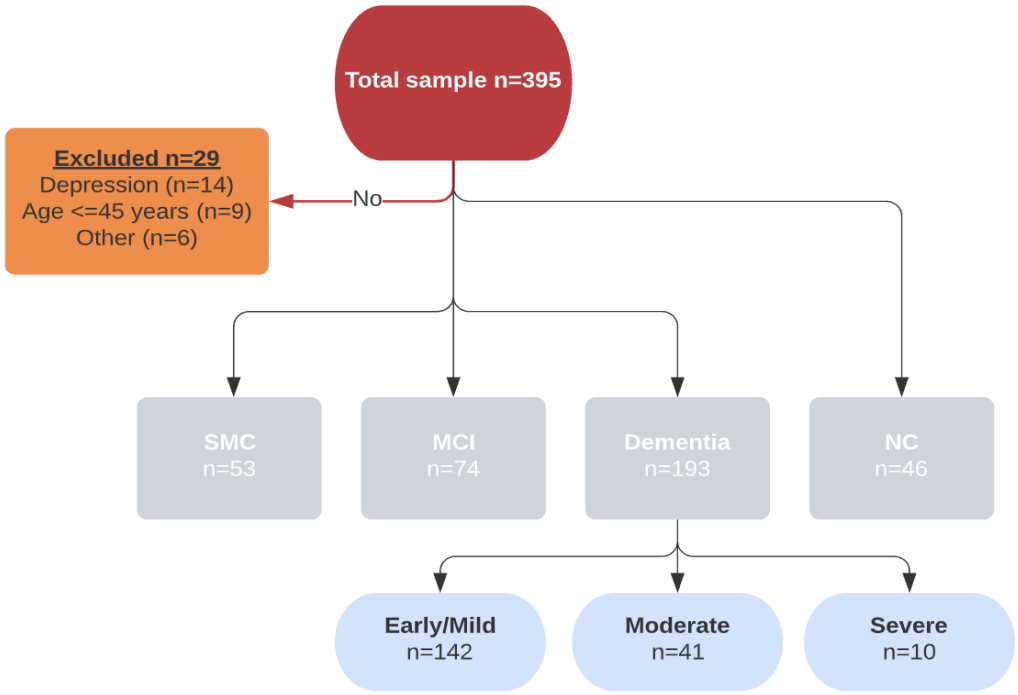


Figure 2. Receiver Operating Characteristic curves showing the accuracy of the Quick Memory Check, Quick Mild Cognitive Impairment (Q*mci*) screen and Montreal Cognitive Assessment (MoCA) in differentiating (a). Mild cognitive impairment (MCI) from normal controls, (b). MCI from subjective memory complaints (SMC), (c). cognitive impairment (MCI & dementia) from normal controls, (d). MCI from dementia, (e). Dementia from SMC and MCI, and (f). SMC from cognitive impairment (MCI & dementia)

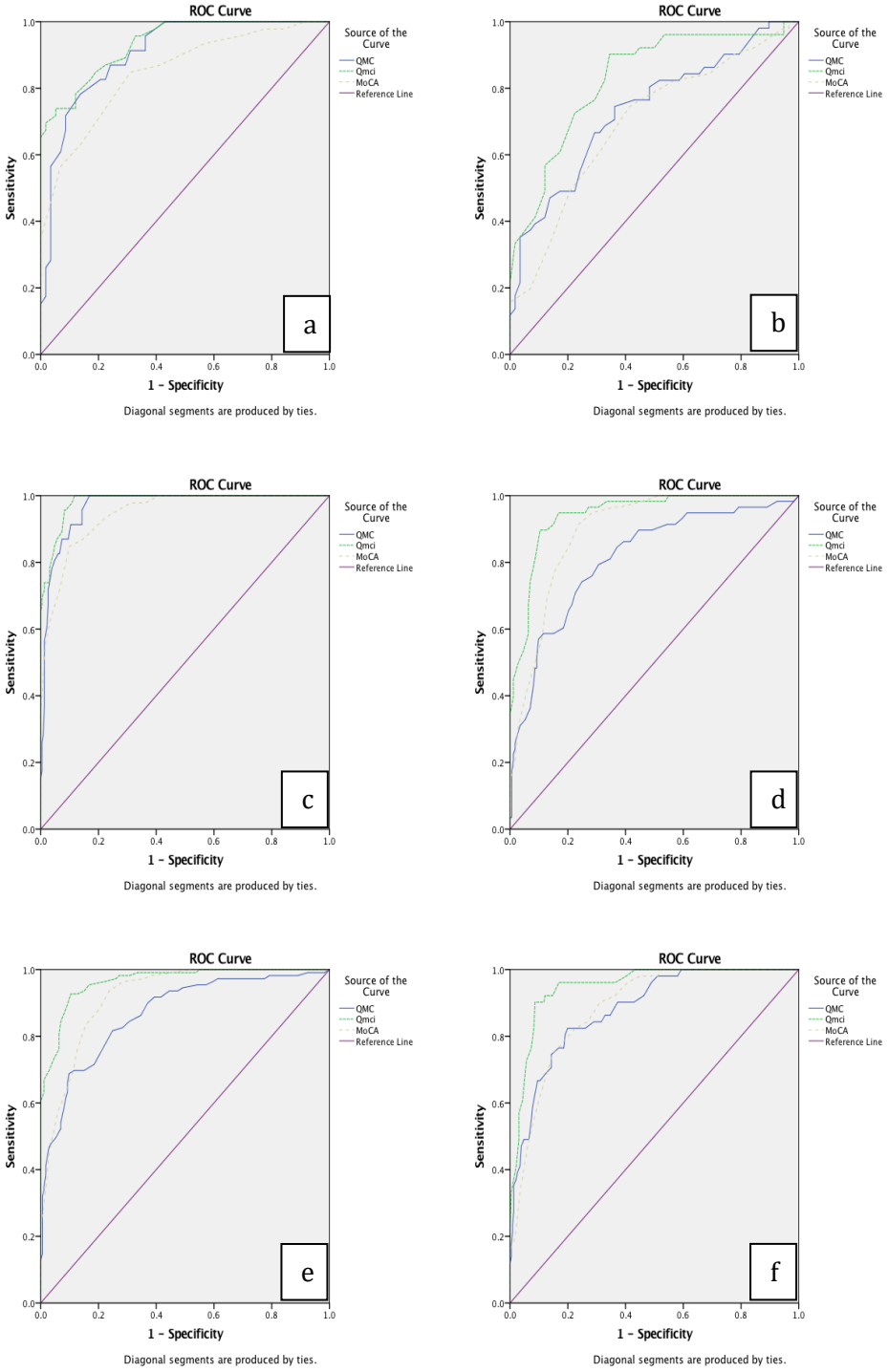
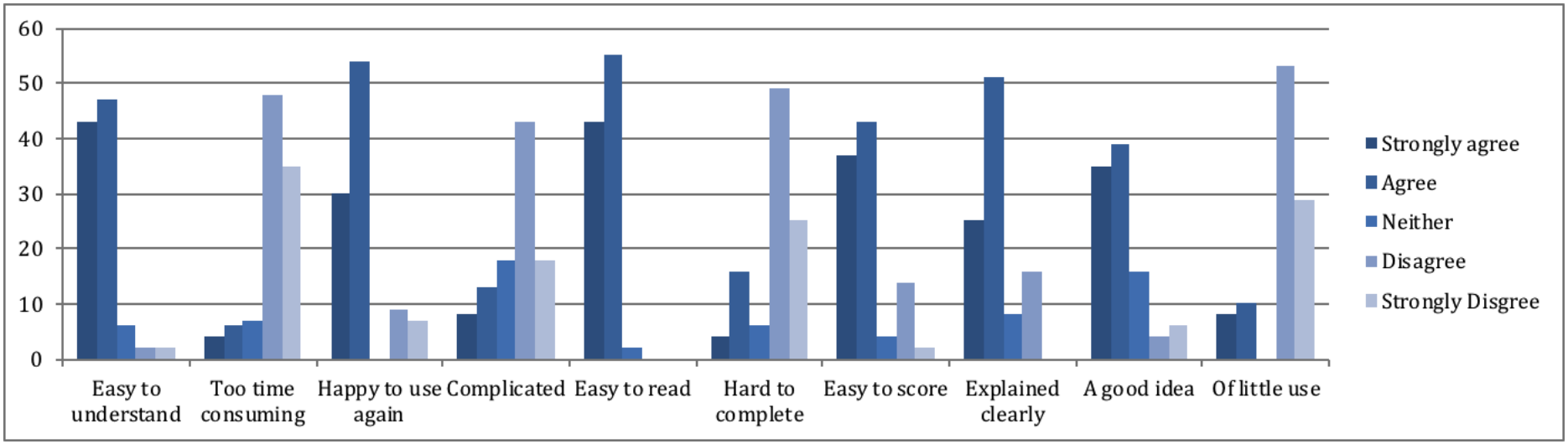


Figure 3. Self-reported questionnaire of ‘caregiver rater’ satisfaction with scoring with Quick Memory Check in advance of clinic



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